

**South Dakota Speech-Language-Hearing
Association**

October 2, 2010

Objective Verification of Digital Hearing Aid Functions And Settings For Individual Patients



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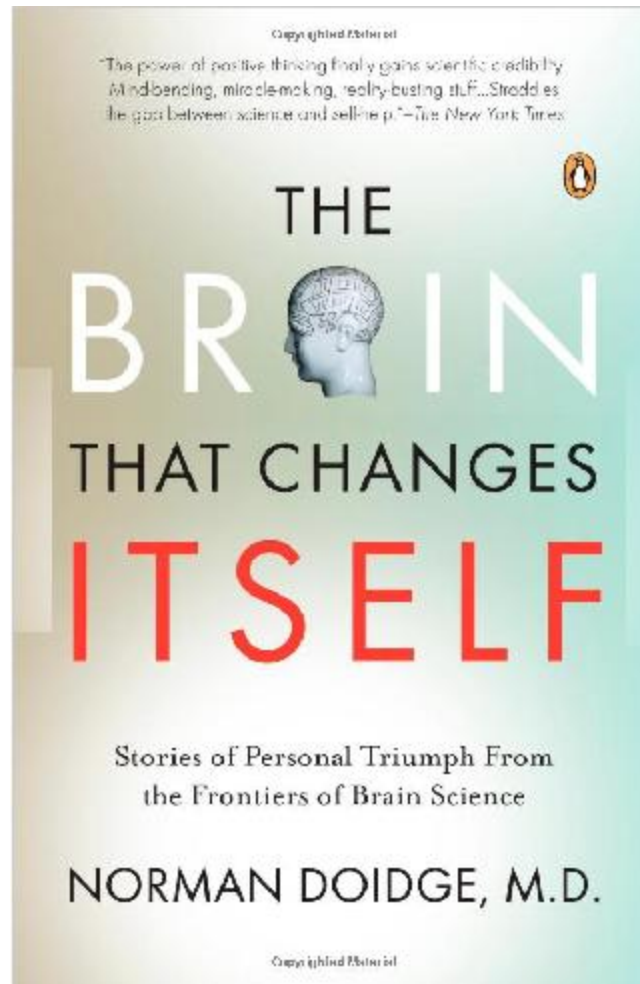


***The Case of a
Woman Perpetually
Falling***



Redesigning The Brain

Inspiring Stories of Cortical Neural Plasticity



The “Fundamentals”

- The goal of amplification is to restore speech audibility
 - ◆ The focus of the fitting process to make this happen, and to verify it
- Gain is a tool used to restore audibility, but its presence does not verify that audibility has been restored

The “Fundamentals”

- Dynamic amplification can only be effectively evaluated in the presence of dynamic stimulation
- Amplification addresses only the peripheral aspects of audibility
- Maximized speech audibility is not appropriate for all peripheral hearing losses

The “Fundamentals”

- Normed “targets” are not always “audibility-targets”
- Objective verification of hearing aid utility is superior to subjective opinions

Modern Objective Wisdom: Measure the Audibility of Speech Directly

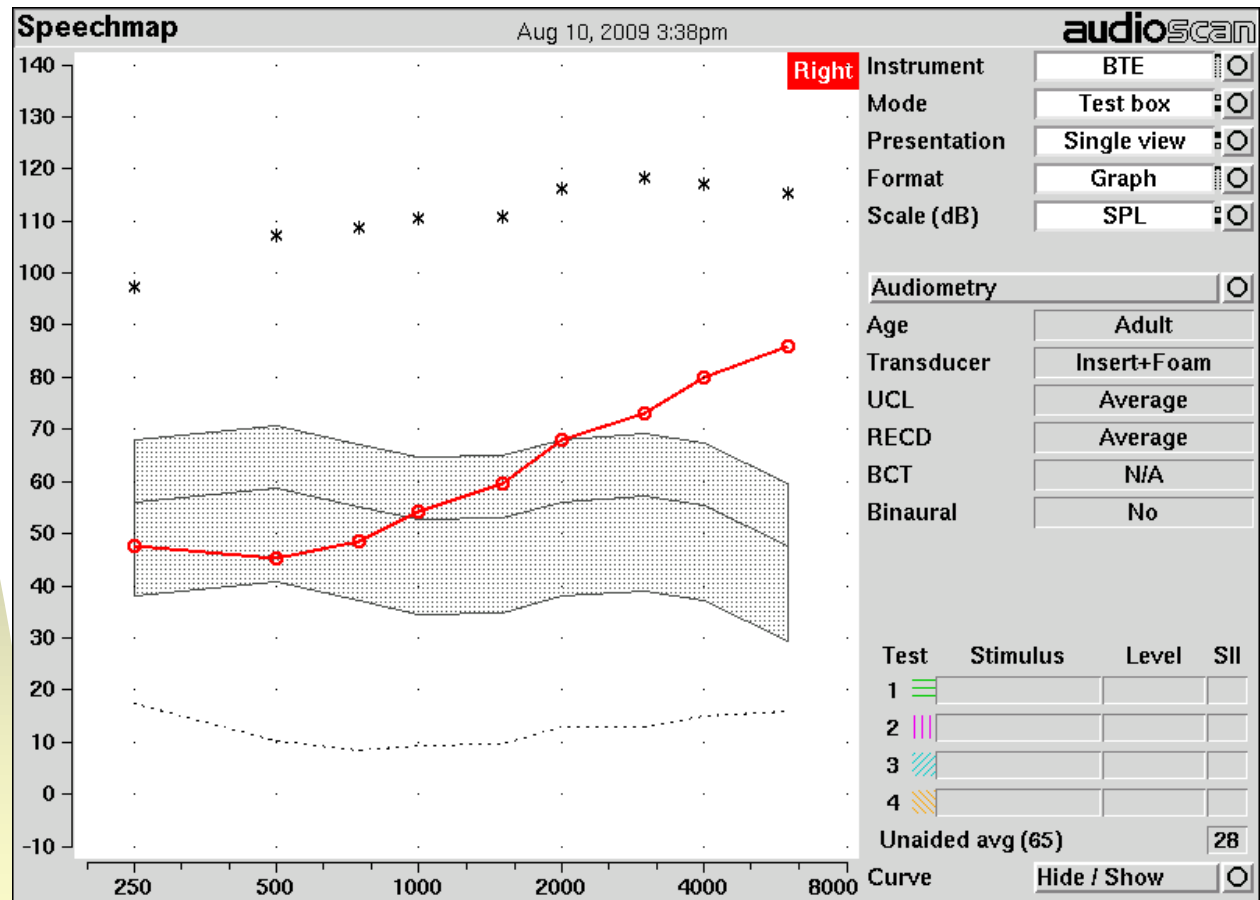
■ Traditional REM Wisdom

- ◆ Input Stimulus
 - ☞ PT sweep
 - ☞ Noise
- ◆ Measure REIG curve
- ◆ Adjust gain to hit a predicted insertion GAIN target

■ Modern On-Ear Wisdom

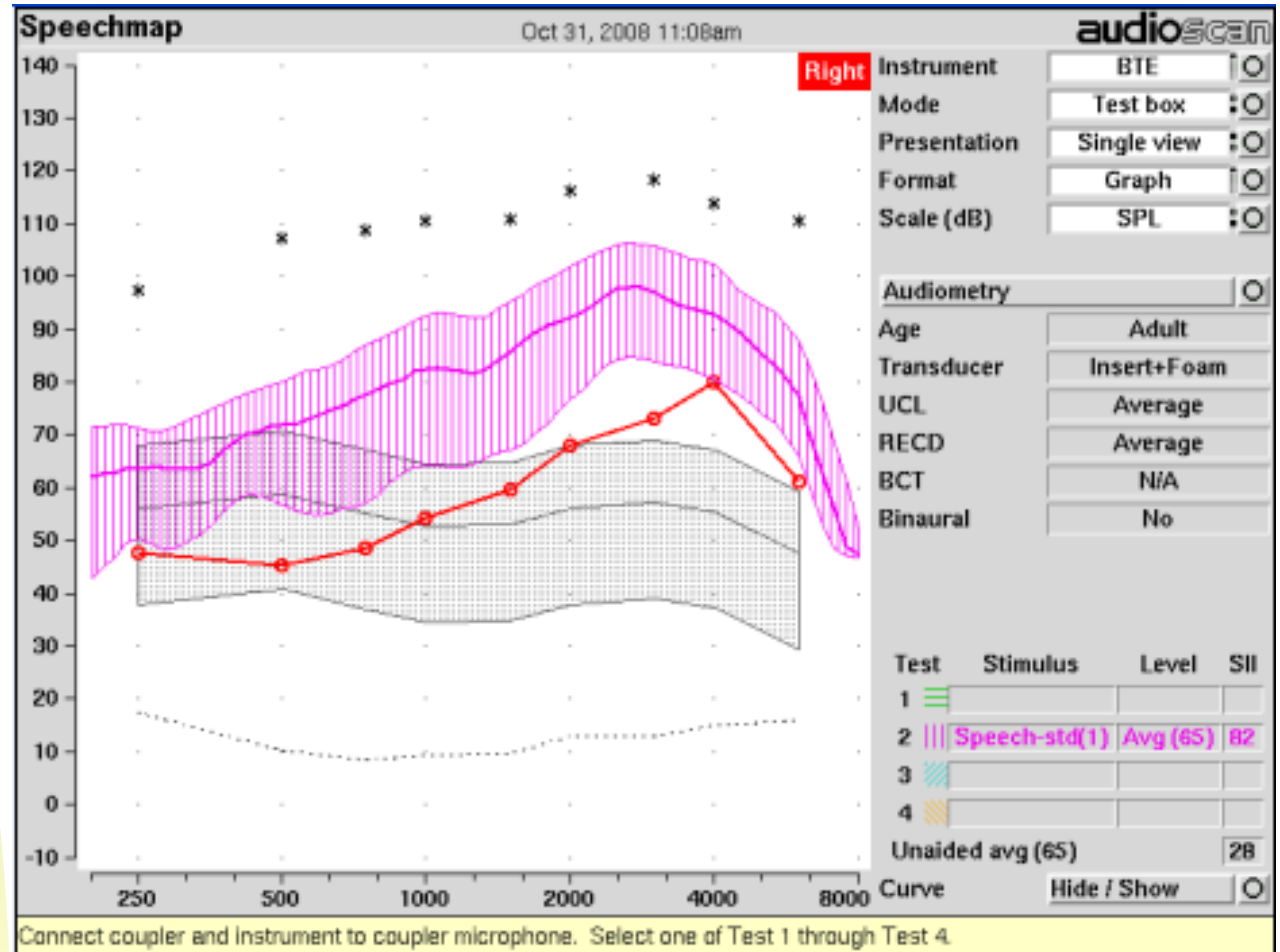
- ◆ Input Stimulus
 - ☞ Speech
 - ☞ “Dynamics”
- ◆ Measure REAR speech banana
- ◆ Adjust gain AND compression to deliver AUDIBILITY to THIS patient

The Basic Speechmap Screen



Connect coupler and instrument to coupler microphone. Select one of Test 1 through Test 4.

The Aided Speech Banana

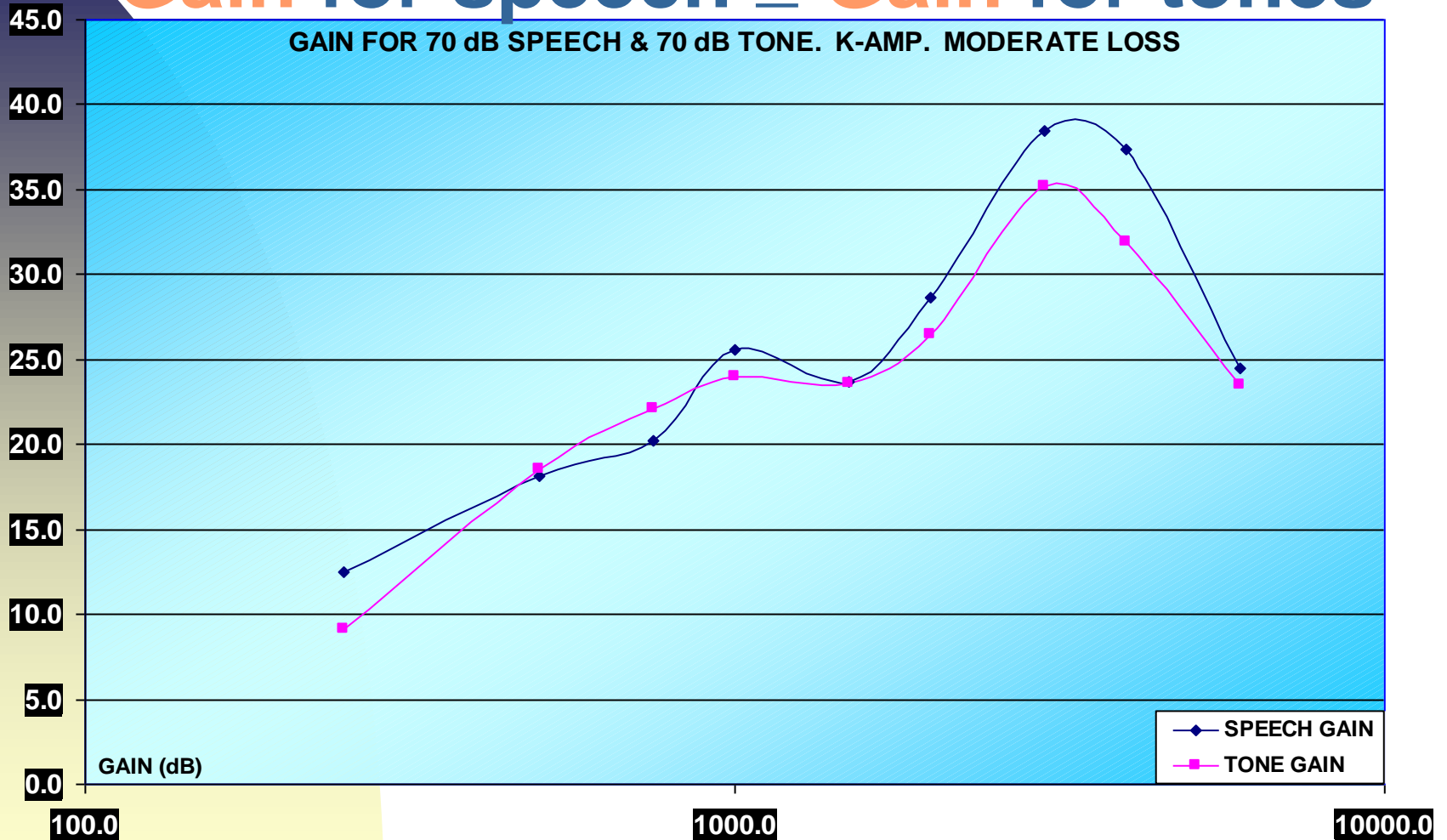




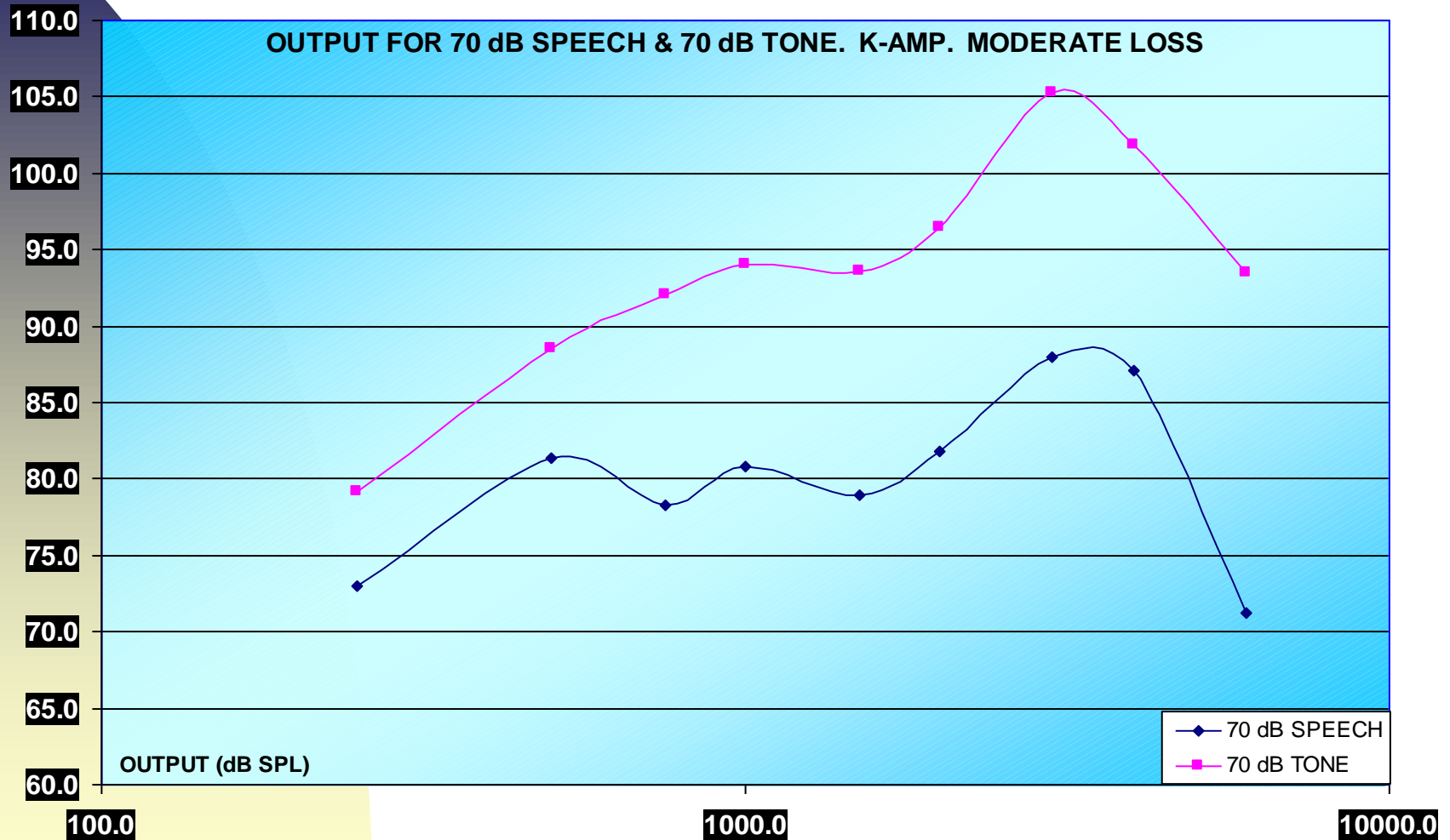
Why Output Instead of Gain?

For this compression hearing aid...

Gain for speech \cong Gain for tones



Output for speech is much less than output for pure tones.



Speech Is An Excellent WDRRC Measurement Stimulus

- It IS the most important input signal that the patient will want to hear well and comfortably
- It interacts with multi-band compressors in a more realistic way than tones
 - ◆ band interactions across frequency
 - ◆ changing intensity

RECD

Real-ear-to-coupler difference

- The difference in dB across frequencies between the SPL measured in the real-ear and in a 2cc coupler, produced by a transducer generating the same input signal.

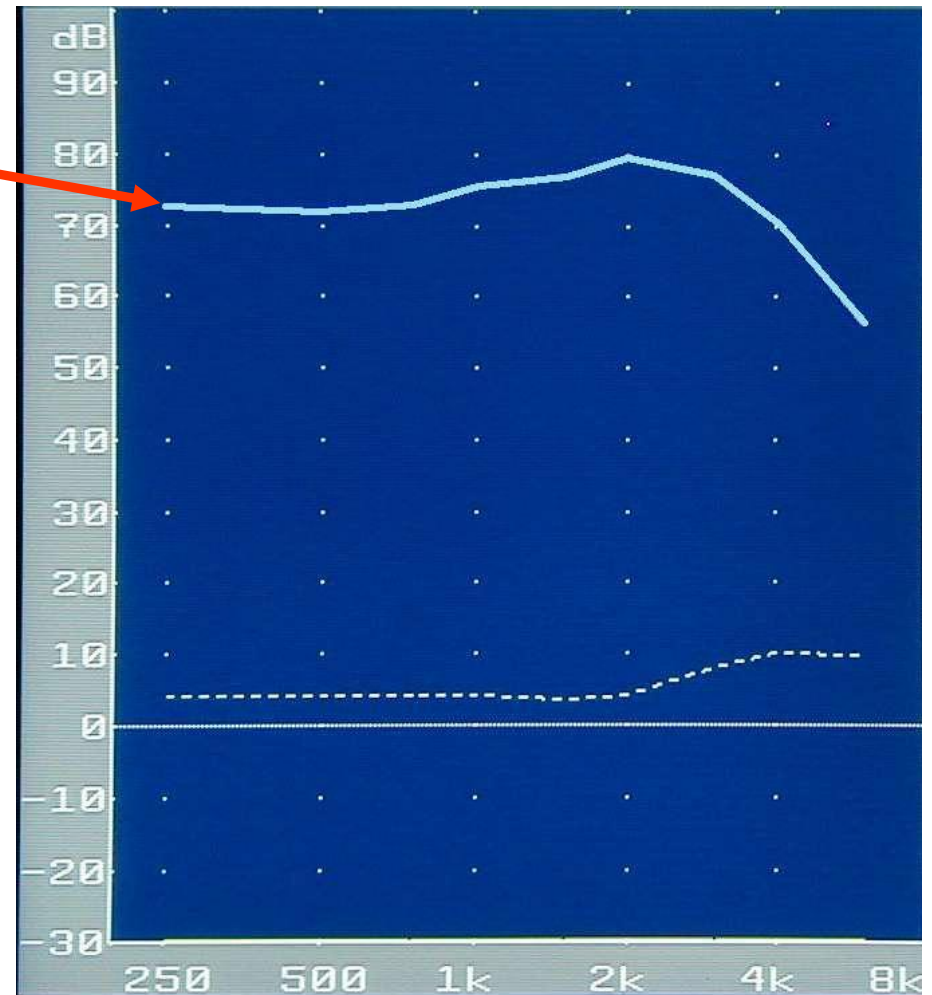
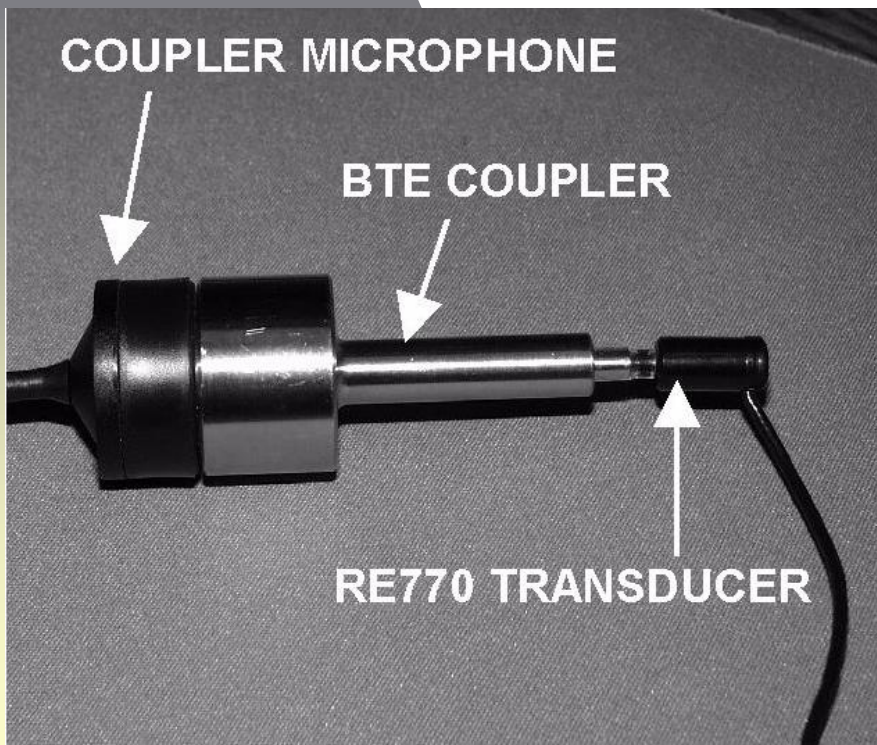
RECD Measurement

How is it done?

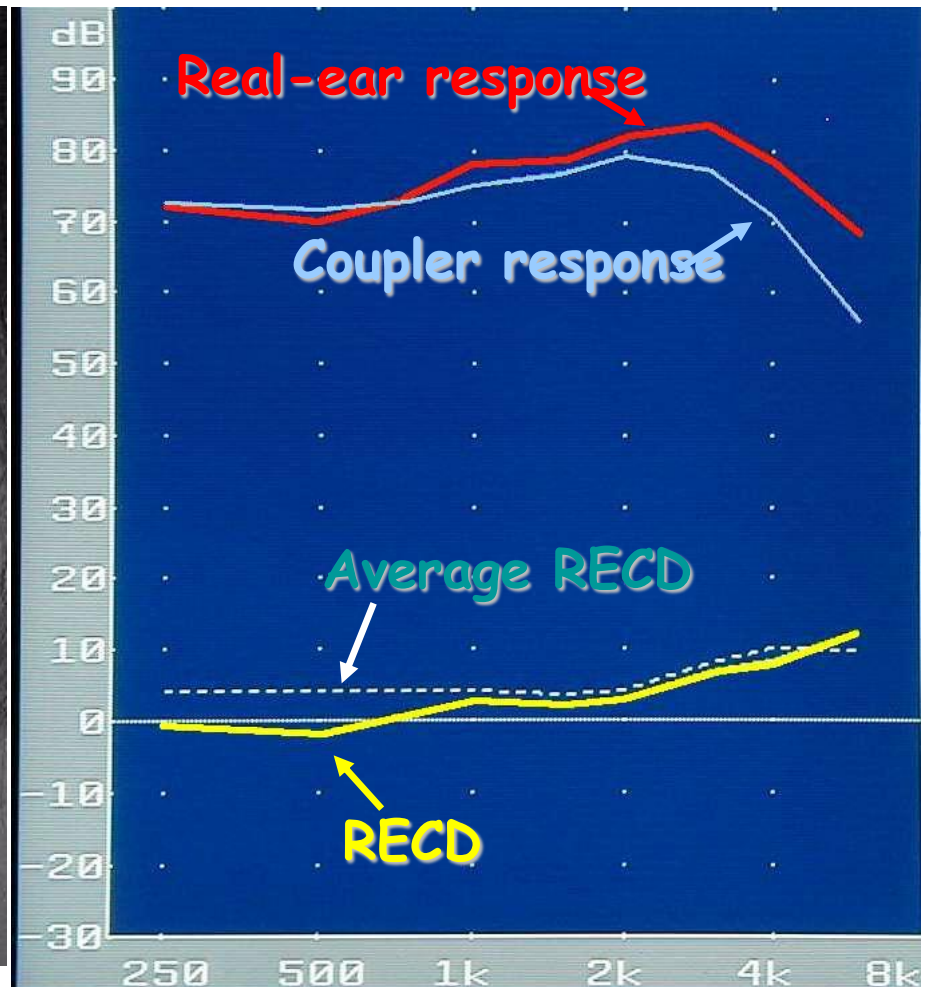
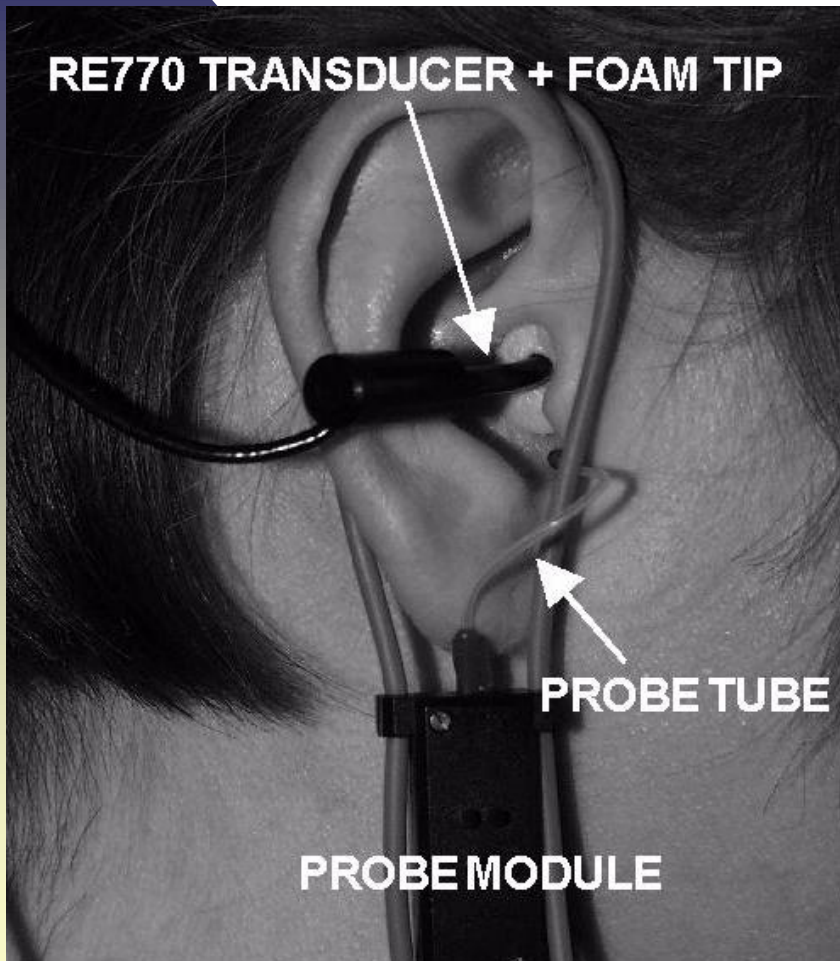
- Composed of 2 measurements:
2cc coupler measurement and
real-ear measurement.

How do we measure RECD ?

Measuring the coupler response of the insert earphone



Measuring the real-ear response of the insert earphone..



The Verifit uses the RECD to...

- Convert threshold and UCL obtained using insert earphones to SPL near the TM
- Convert test box measurements of hearing aid output to estimated real-ear aided response

**1) Recruitment
Accommodation**

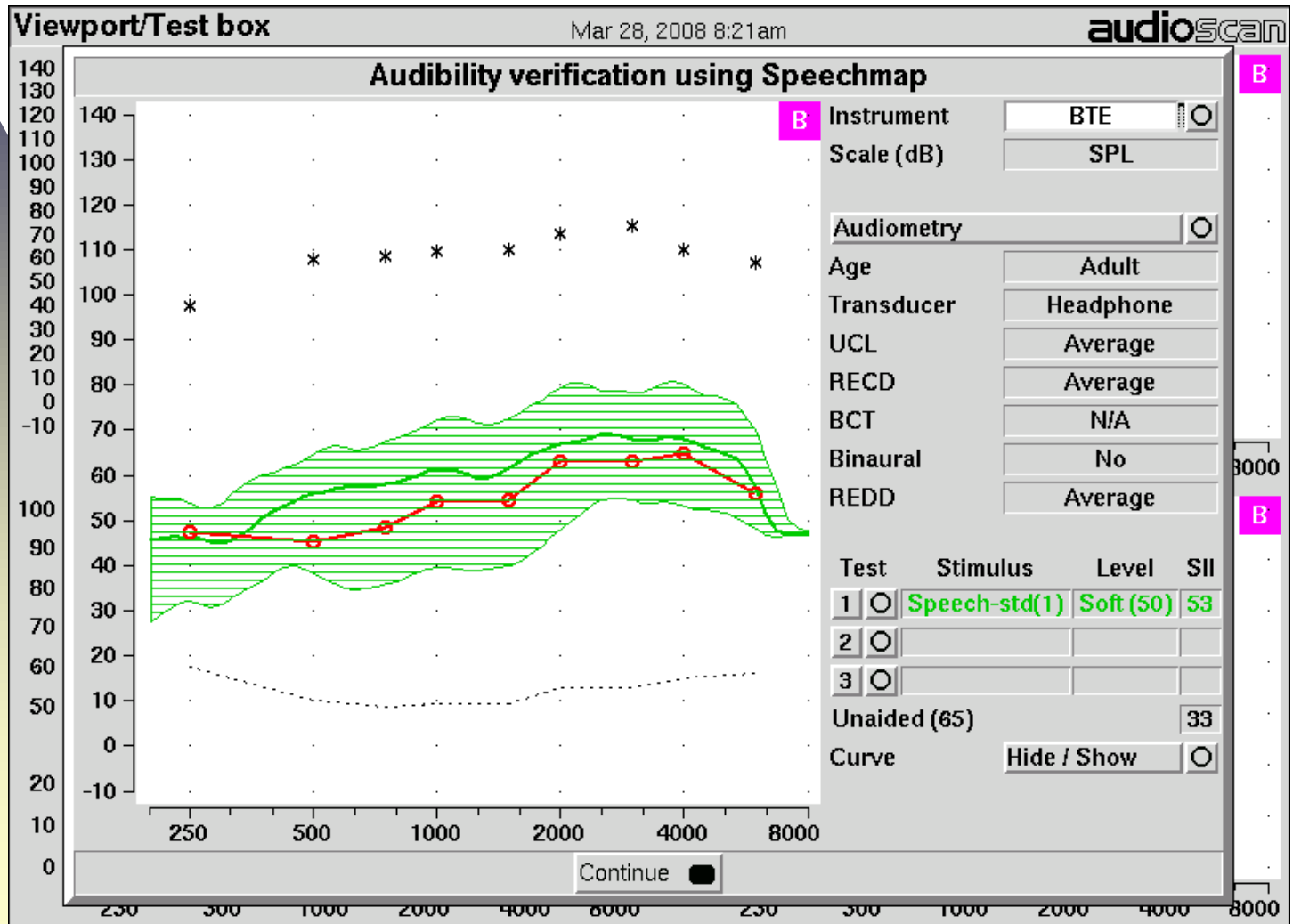
RECD: Things to Remember

- Measured RECD is only applied if “Insert-Foam” has been selected as the transducer
- Measured RECD is only valid if it is measured as described in the manual (i.e. with the foam tip)

Speechmap Fitting Protocol

- Test 1:
 - ◆ Input: 50dB STD speech
 - ◆ Goal: To adjust the gain of the aid so that at least the middle line of the aided speech banana hovers above the SPL threshold line

Test 1 Result

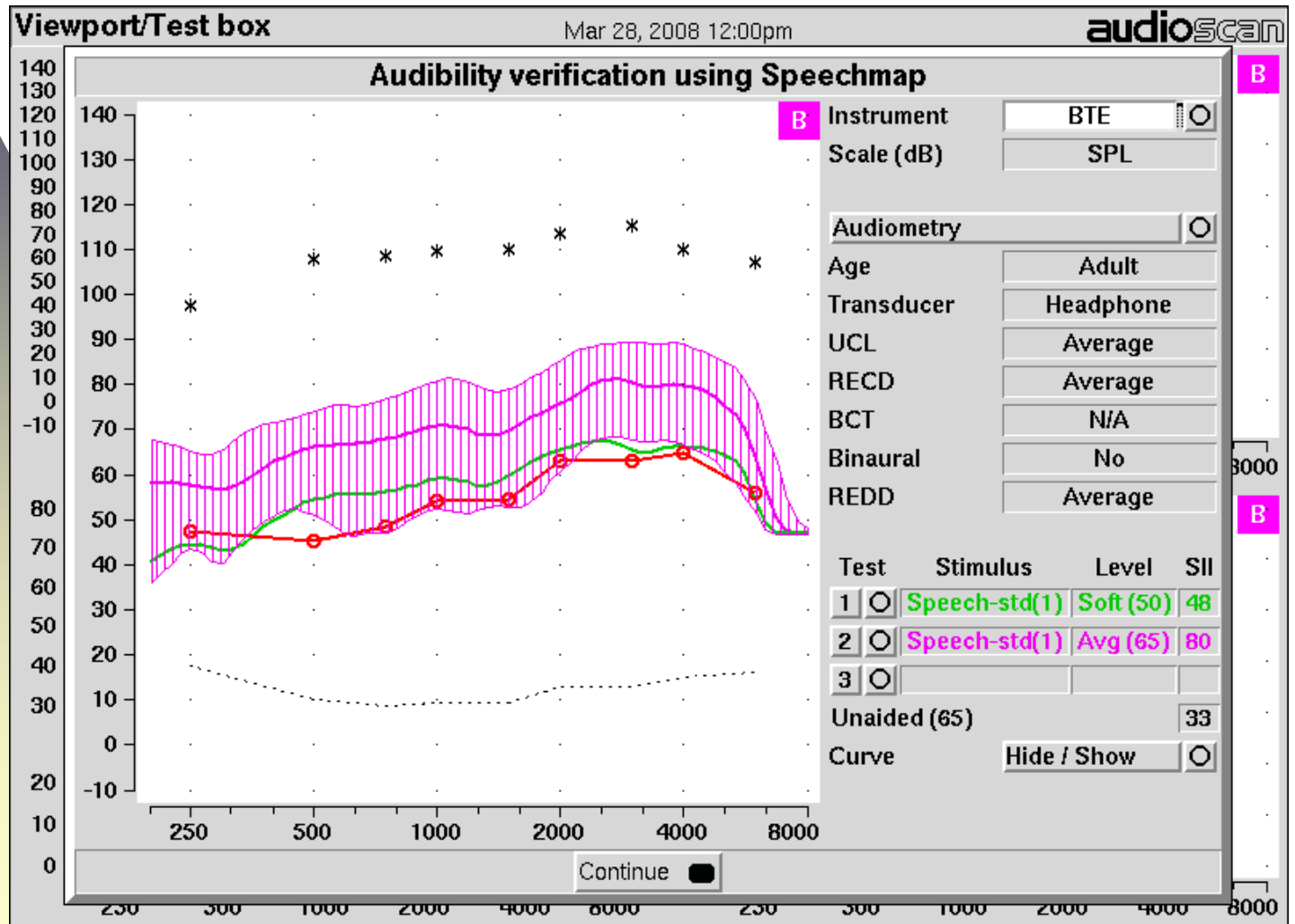


Select one of Test 1 through Test 3.

Speechmap Fitting Protocol

- Test 2:
 - ◆ Input: 65dB STD speech
 - ◆ Goal: To verify that the bottom line of the aided speech banana is just above threshold
 - ☞ Use compression settings to adjust the width of the banana

Test 2 Result

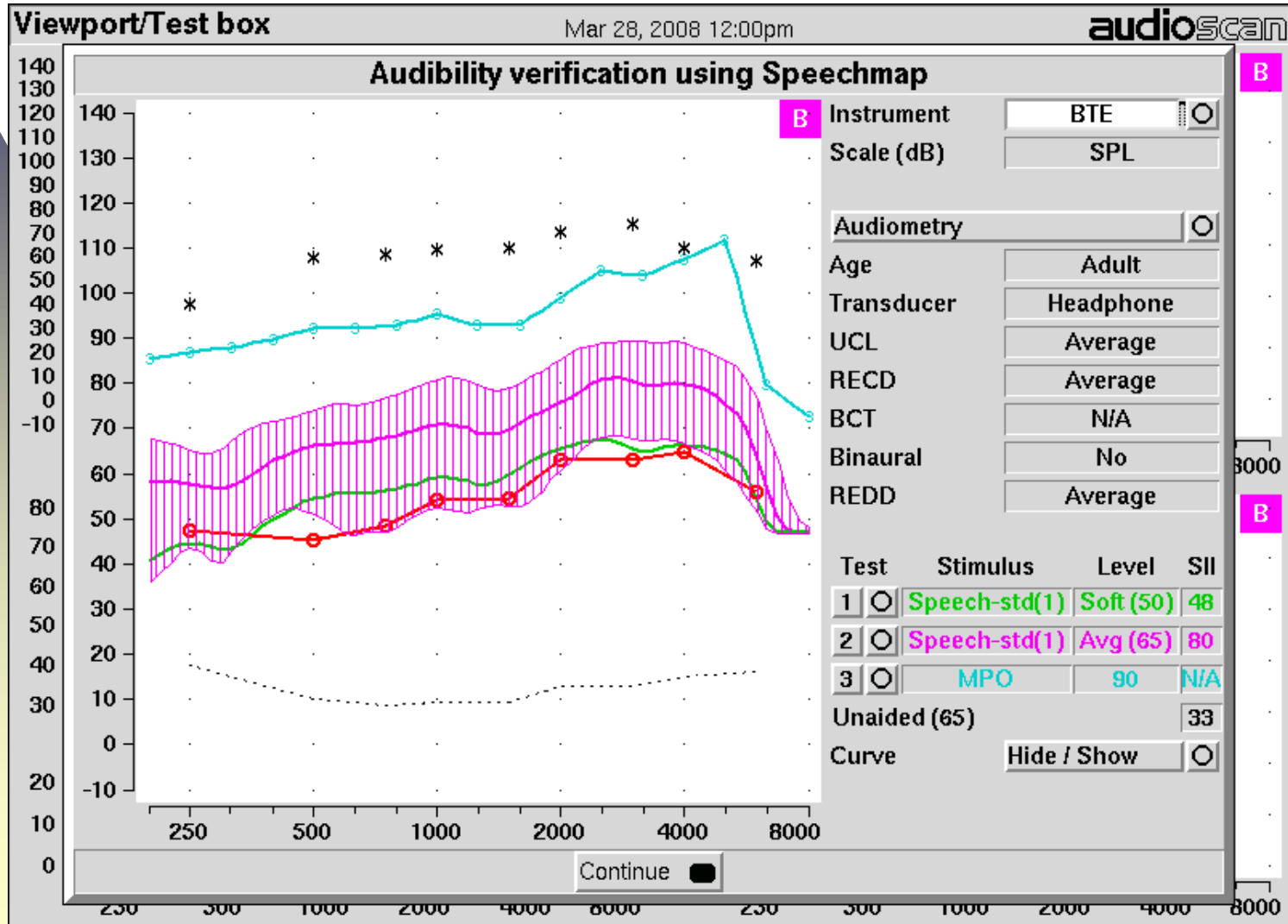


Select one of Test 1 through Test 3.

Speechmap Fitting Protocol

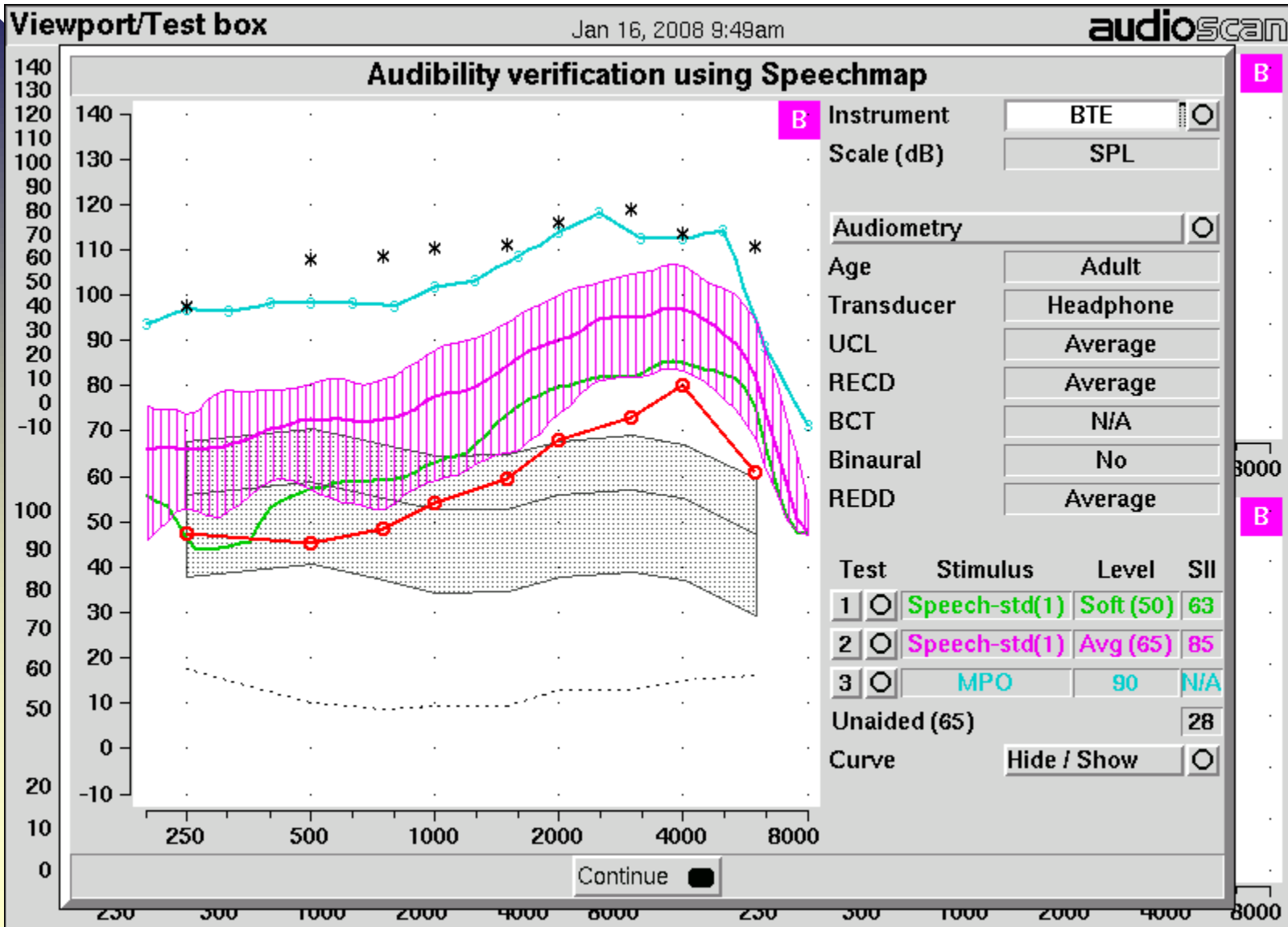
- Test 3:
 - ◆ Input: MPO Sweep
 - ◆ Goal: To adjust the MPO of the aid so that the blue dots come as close as possible to the UCL asterisks without being above them

Test 3 Result



Select one of Test 1 through Test 3.

The Counseling Screen

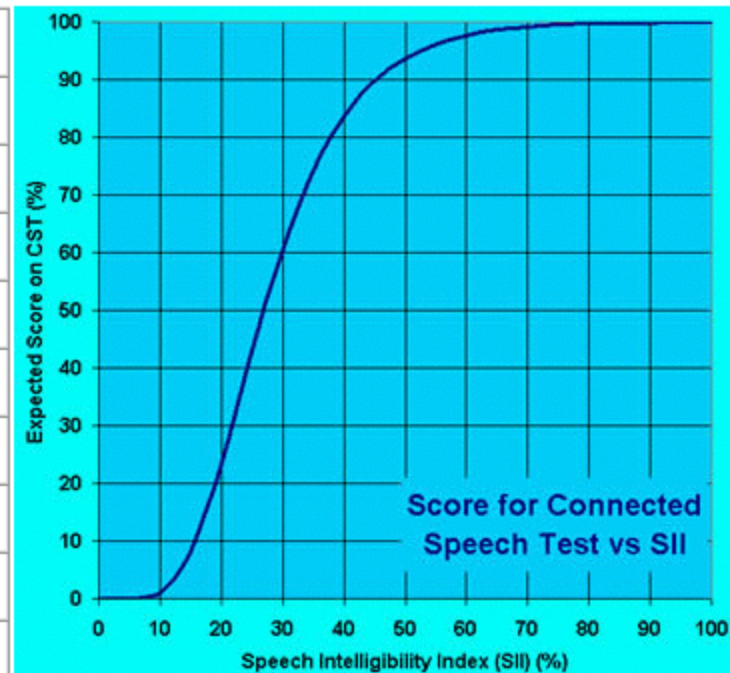


RECD facts
 RECD coupler response
 RECD on-ear response
 RECD results
 16 Insertion Gain
 Section overview
 Insertion gain in SPL
 Insertion gain in HL
 Audiometric data entry
 REUR measurement procedure
 REAR measurement procedure
 SII calculation in Insertion gain
 CROS fitting using Insertion gain
 17 Speechmap
 Section overview
 Speechmap facts
 DSL in Speechmap
 DSL changes
 NAL-NL1 in Speechmap
 Camfit in Speechmap
 Using Speechmap
 Screen tour - unaided screen
 Screen tour - aided screen
 On-ear or Test box mode
 SII calculation in Speechmap
 18 Speechmap Fitting Procedure
 Section overview
 Assessment data entry

17 Speechmap

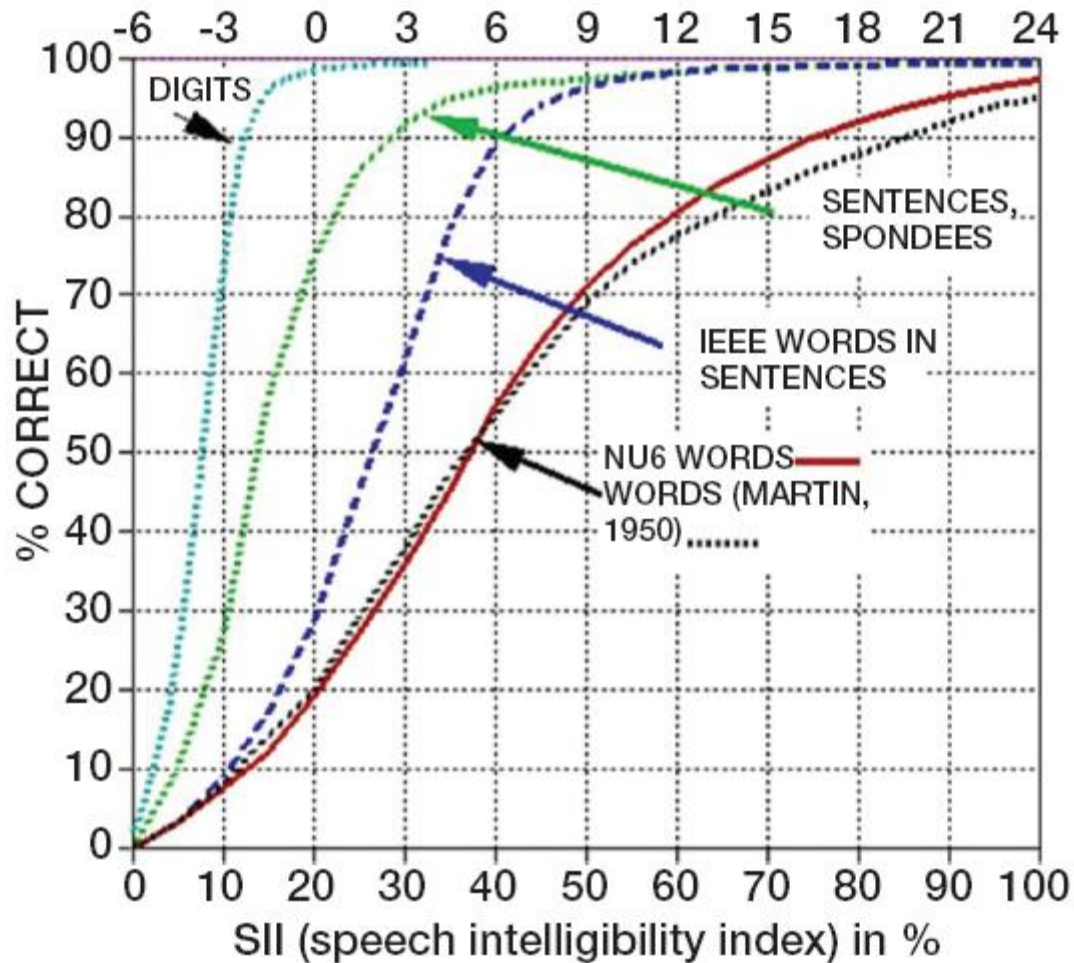
The speech recognition associated with a given SII is a function of the test material and the cognitive abilities of the listener. There is considerable individual variability in relating the SII to speech recognition, especially amongst impaired listeners. The following shows expected nominal recognition scores vs SII for normals on the Connected Speech Test (Sherbecoe and Studebaker 2003).

SII (%)	Score (%)
10	1
15	8
20	20
25	45
30	60
35	74
40	84
45	90
50	94
55	96
60	98
70	99



Cancel Help

Select a topic using the arrow keys. Topics may be printed but figures may be incomplete. For more help, press Help again.



Killion, M., Mueller, H.G., "Twenty Years Later: The New Count-The-Dots Method", Hearing Journal, January 2010, pp 10-15

What Does the Speechmap Protocol Provide You?

- Verification that soft speech energy is audible to the patient
- Verification that average speech energy is comfortably positioned within the patients audible range
- Verification that UCL levels can not be exceeded, regardless of stimulus type
- Verification that the patient's recruitment has been accommodated

1) Recruitment
Accommodation

Recruitment Accommodation Clinical Protocol

- At initial assessment visit:
 - ◆ Obtain RECD measurement
- Prior to fitting visit
 - ◆ Program aid and do Speechmap protocol in Test-Box mode
- At fitting visit
 - ◆ Do Speechmap protocol in On-Ear mode

Cochlear Dead Regions

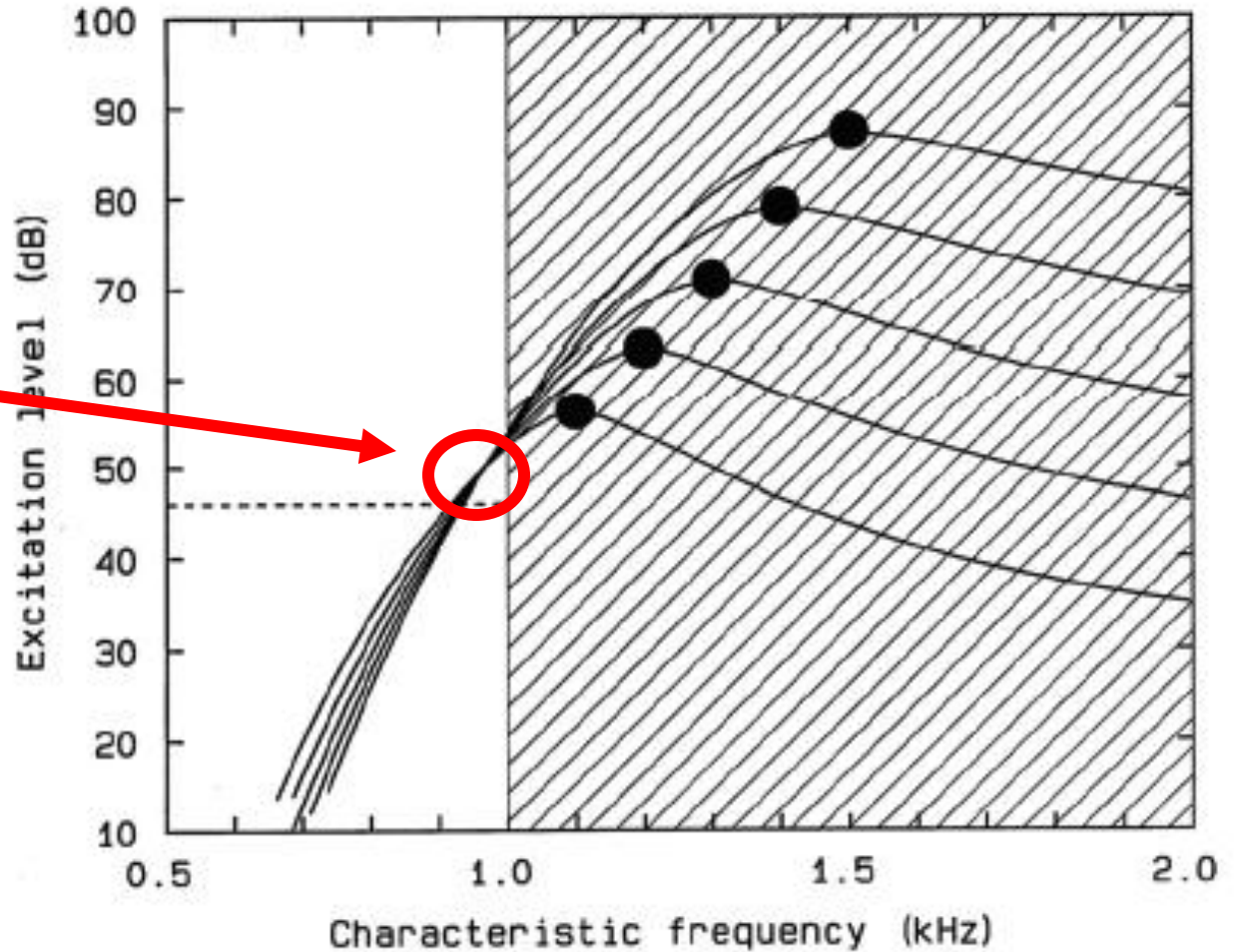
- Regions in cochlea where inner hair cells and/or neurons are effectively not functioning at all
- Vary considerably from person to person
- Most often located toward the basal end of the basilar membrane

How Common Are Dead Regions?

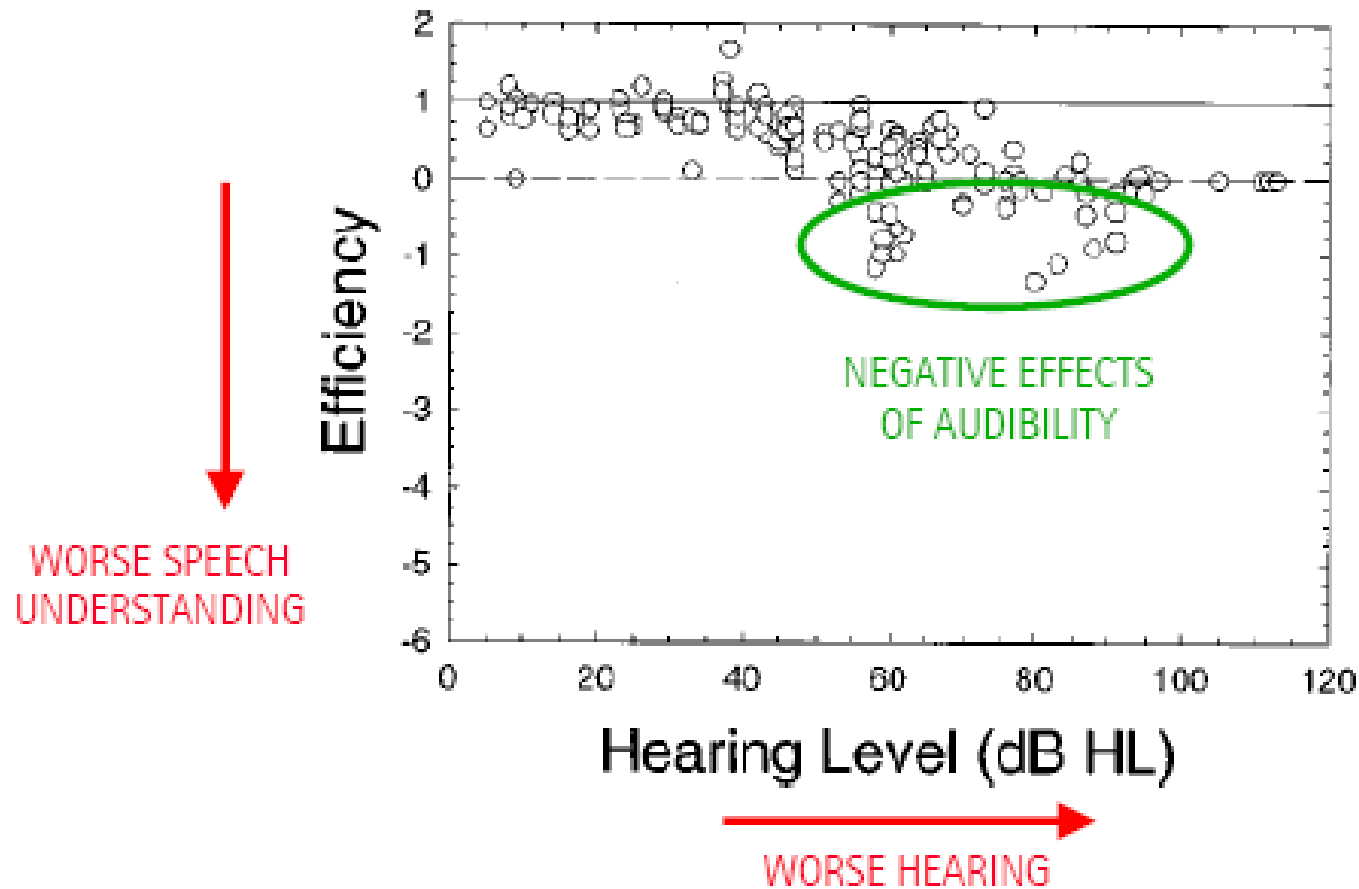
For HL thresholds . . .	The likelihood of dead regions is . . .
55dB or less	Rare
55dB to 75dB	Possible
Greater than 75dB	Increasingly Common

Dead Region “Audibility”

“Off Frequency”
Listening



Is high-frequency amplification always beneficial?



from Hogan & Turner, JASA 1998

The TEN Test

- Threshold-Equalizing Noise (TEN) Test
 - ◆ A masked threshold is approximately equal to the nominal level of the TEN noise stimulus
 - ☞ 70dB noise should produce app. 70dB threshold at all test frequencies
 - ◆ A masked threshold that is at least 10dB higher than normal is **POSITIVE** for a cochlear dead region

Moore, BCJ, et.al., "New Version of TEN Test with Calibration in dB HL"
Ear and Hearing, 2004::25, 478-487

Verifying Digital Performance

**Verifying Frequency
Lowering and Frequency
Transposition Functions**



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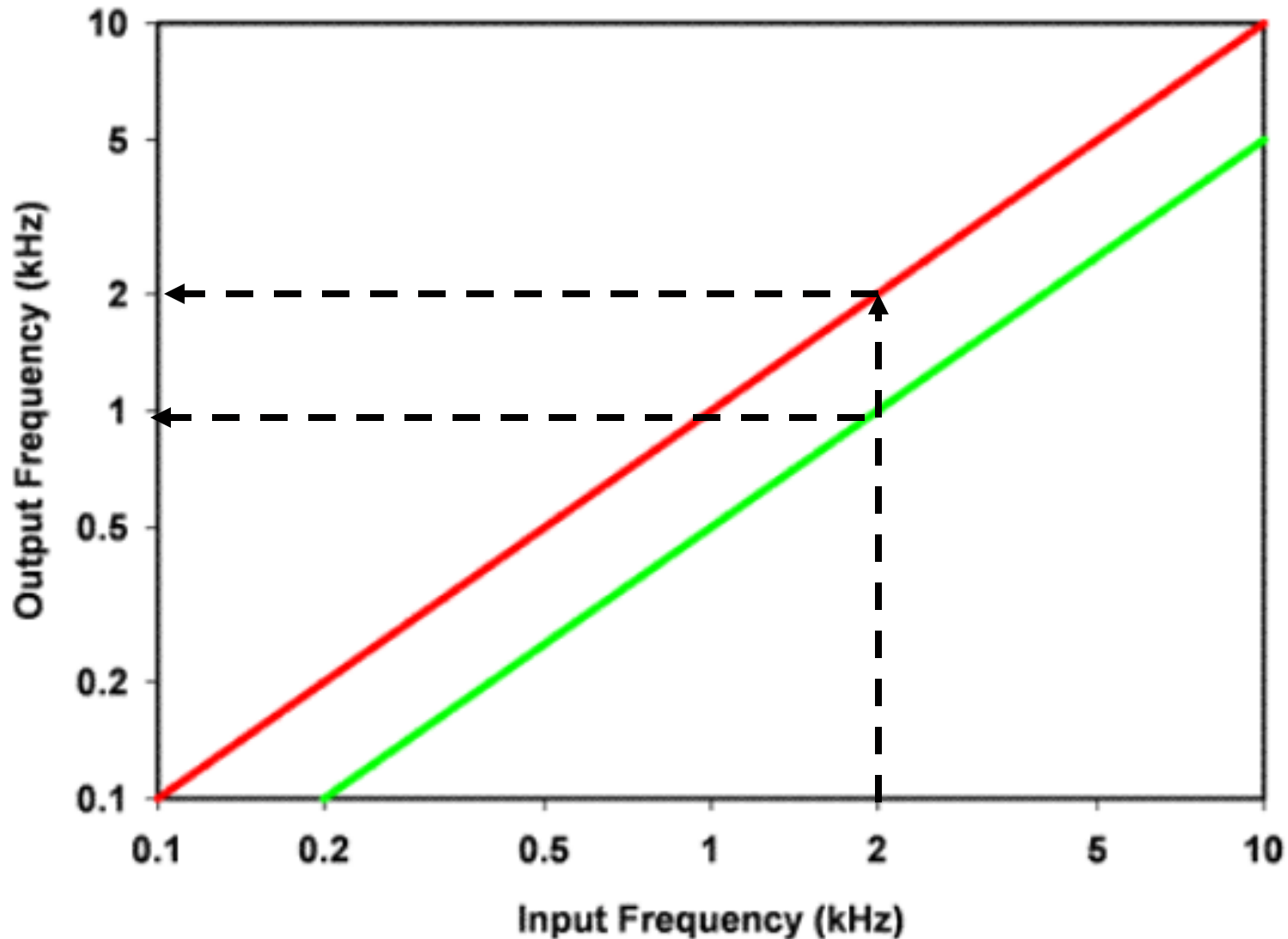
The Concept Behind Changing Output Frequency Content

- Some hearing losses have un-aidable regions where important speech information exists
- Re-positioning input energy in these regions to regions that are aidable can provide access to these important speech cues

The Solution: Frequency Shifting

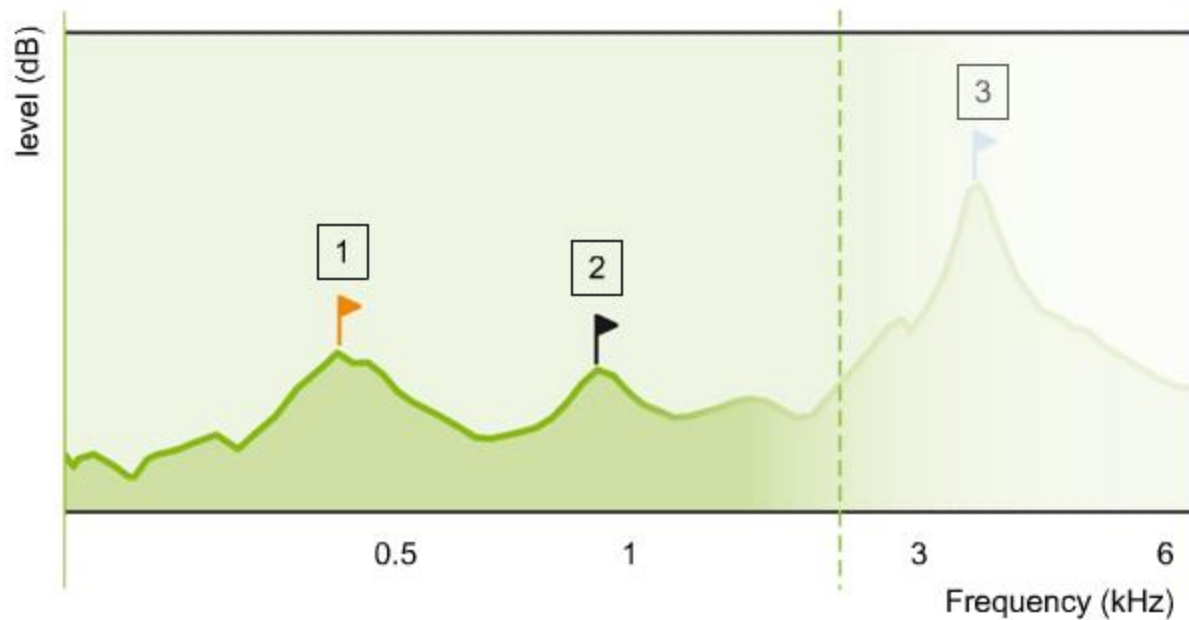
- For many people with severe-to-profound hearing impairment in the higher frequencies, frequency shifting can improve signal audibility
- Numerous different frequency lowering schemes have been developed and evaluated
- Some of these schemes have been shown to improve speech understanding

Practical frequency-shifting techniques



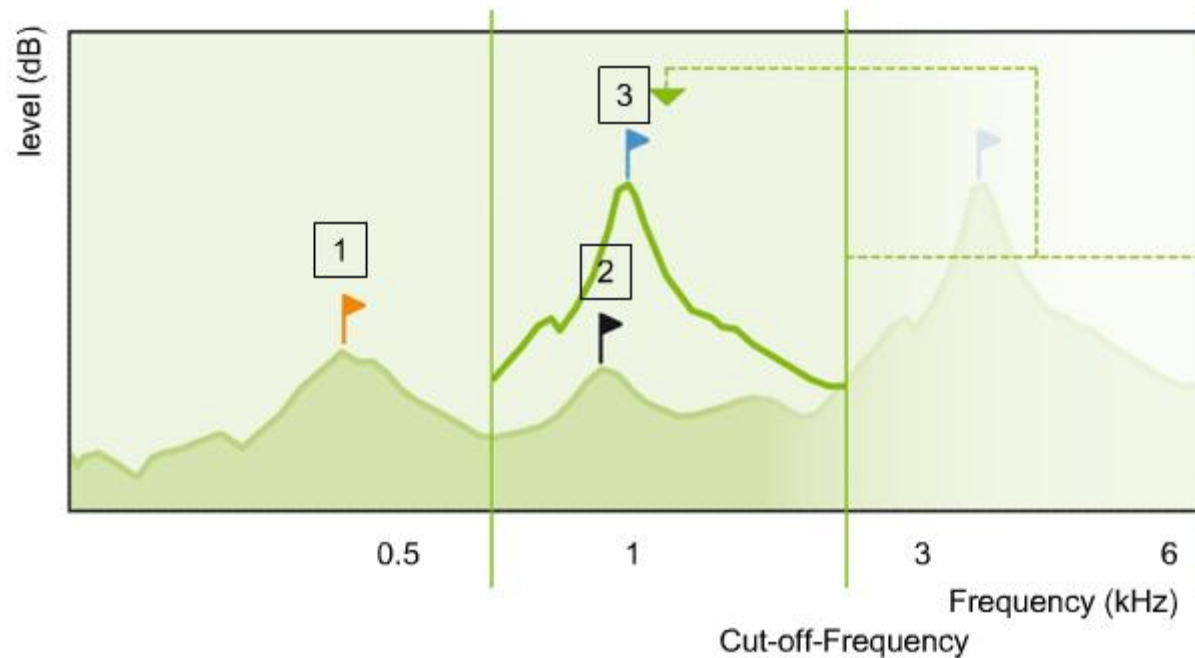
Frequency Shifting Approaches

- Frequency Transposition

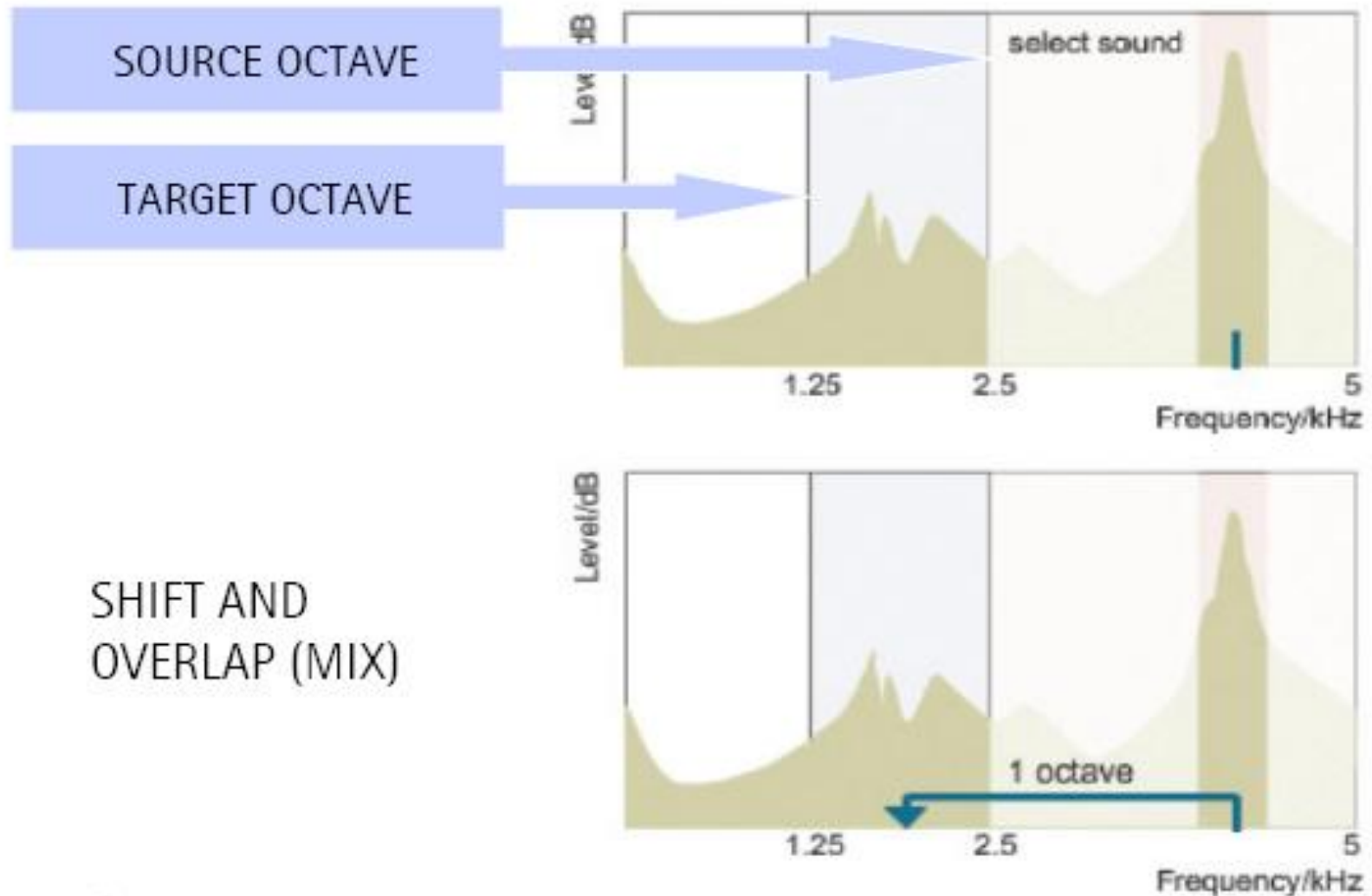


Frequency Shifting Approaches

- Frequency Transposition

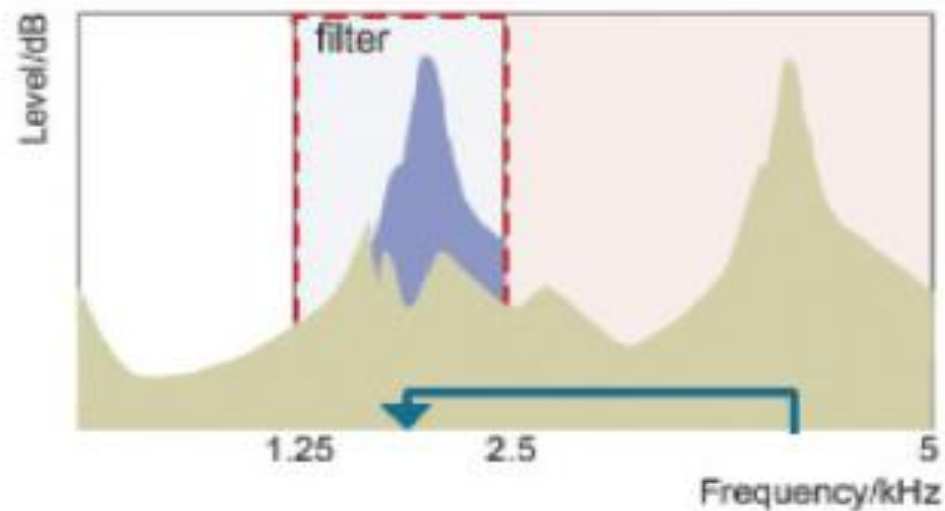


Widex *Inteo* 'Audibility Extender'



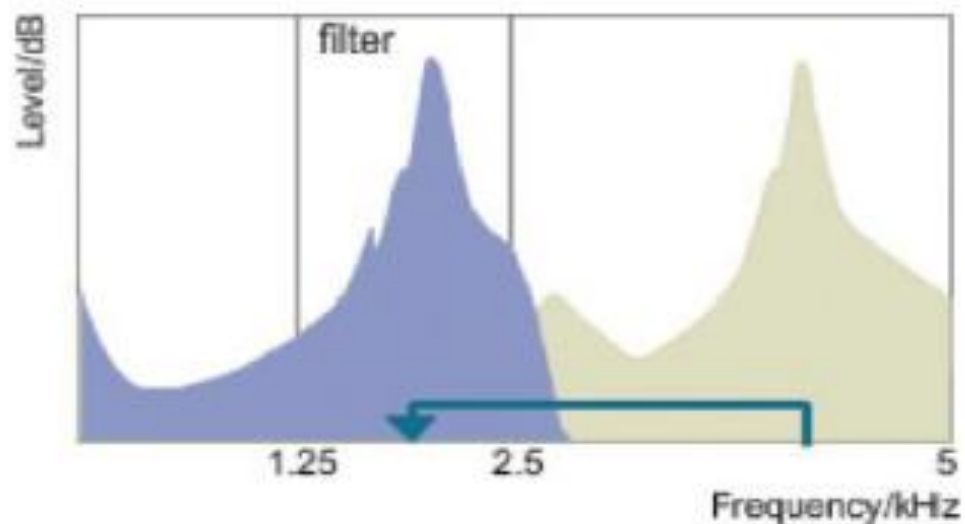
Widex AE - continued

FILTER OUTPUT
SIGNAL 'TO LIMIT
MASKING EFFECT'



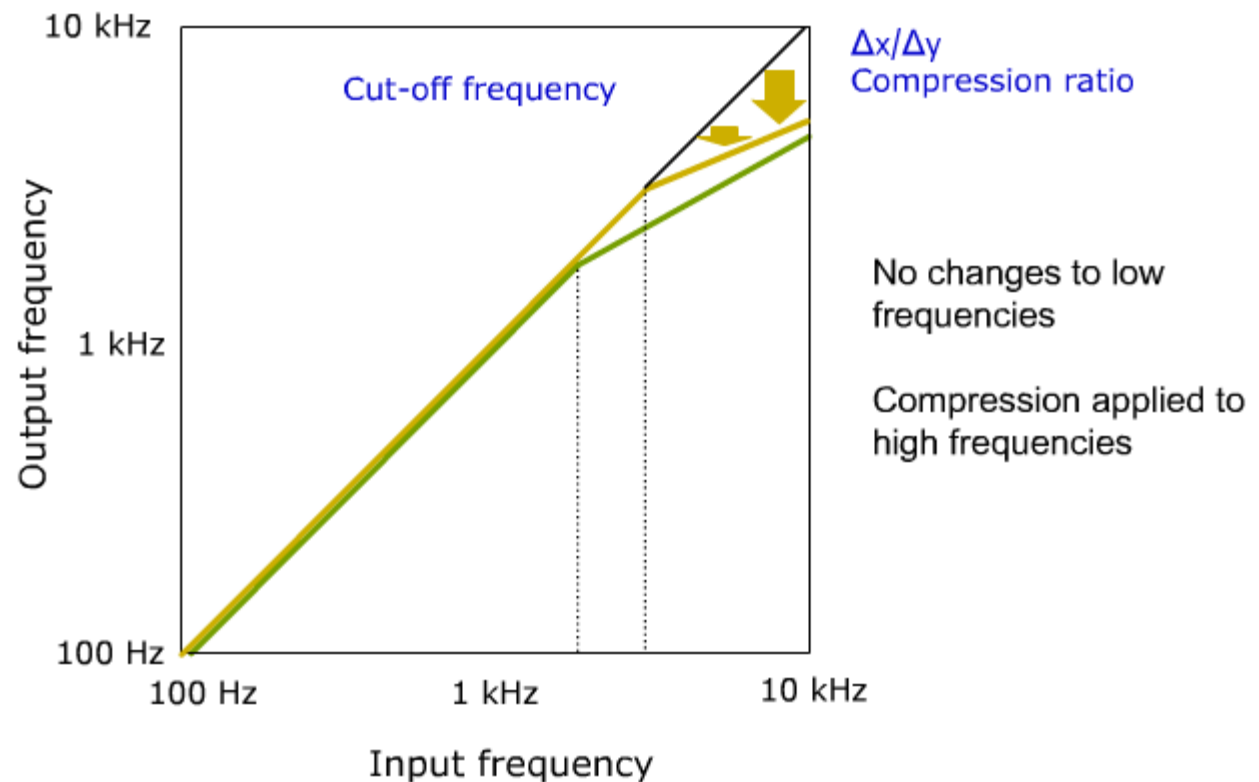
OUTPUT SPECTRUM:

INPUT SPECTRUM:



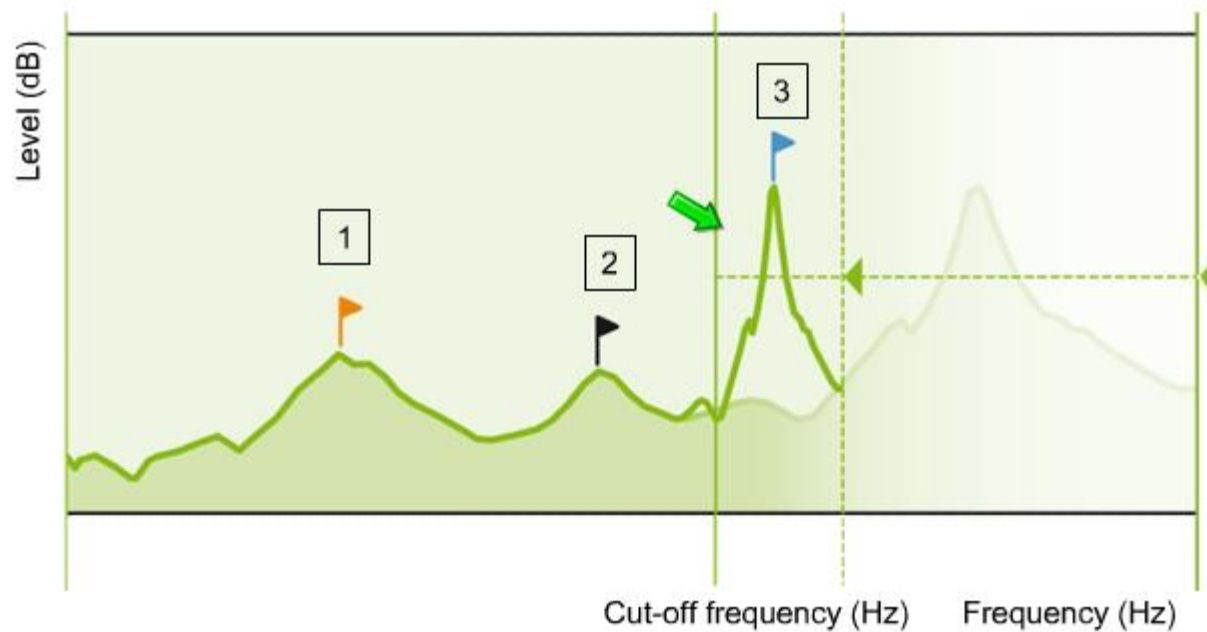
Frequency Shifting Approaches

- Frequency Compression



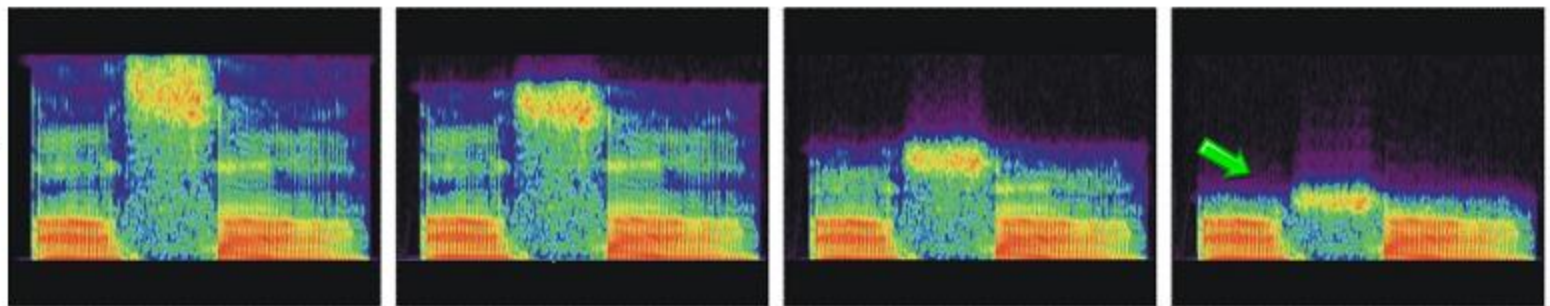
Frequency Shifting Approaches

- Frequency Compression



Effect of parameters when processing /aSa/

Frequency



Original

4000

2000

1500

1.5:1

2:1

4:1

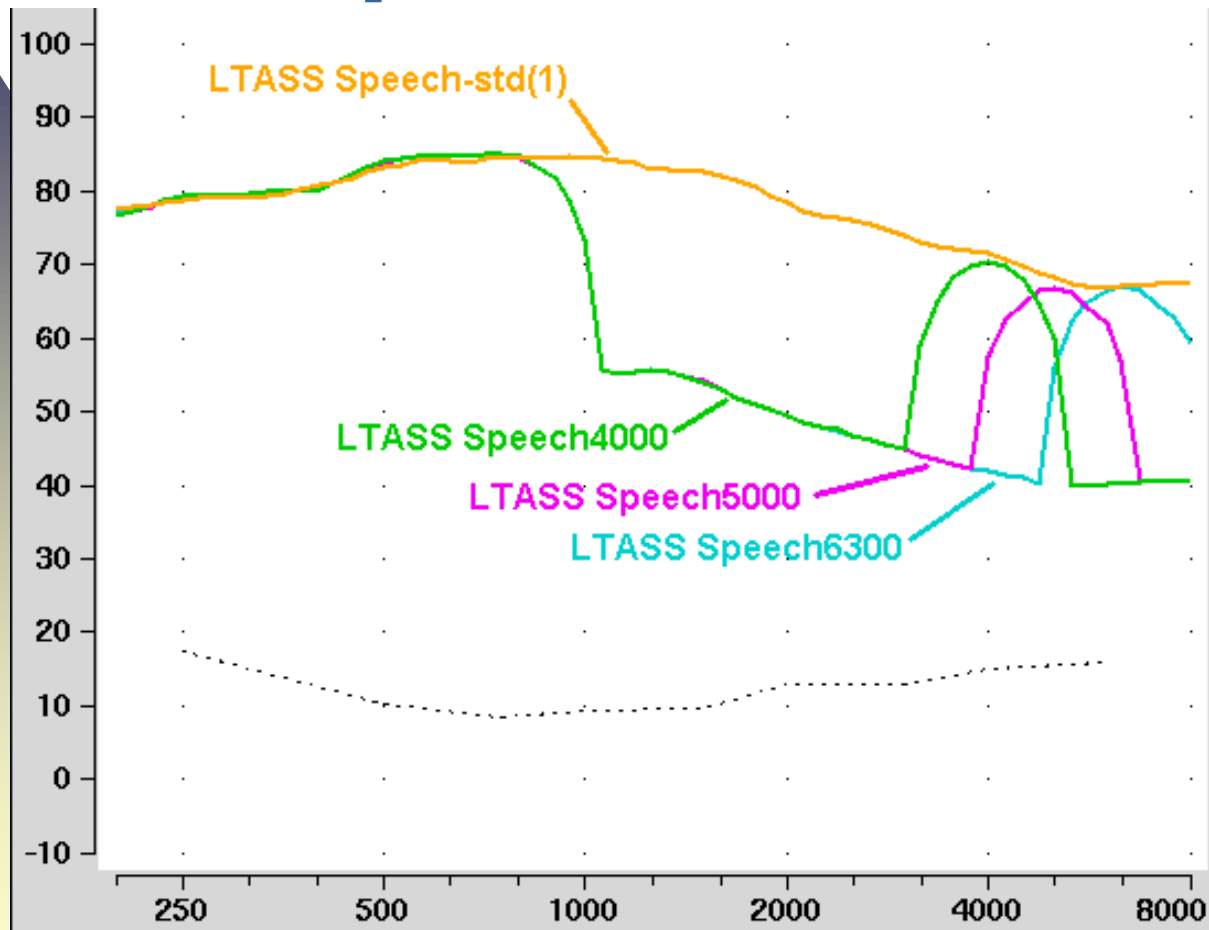
Time

Lower cut-off frequencies = stronger frequency compression

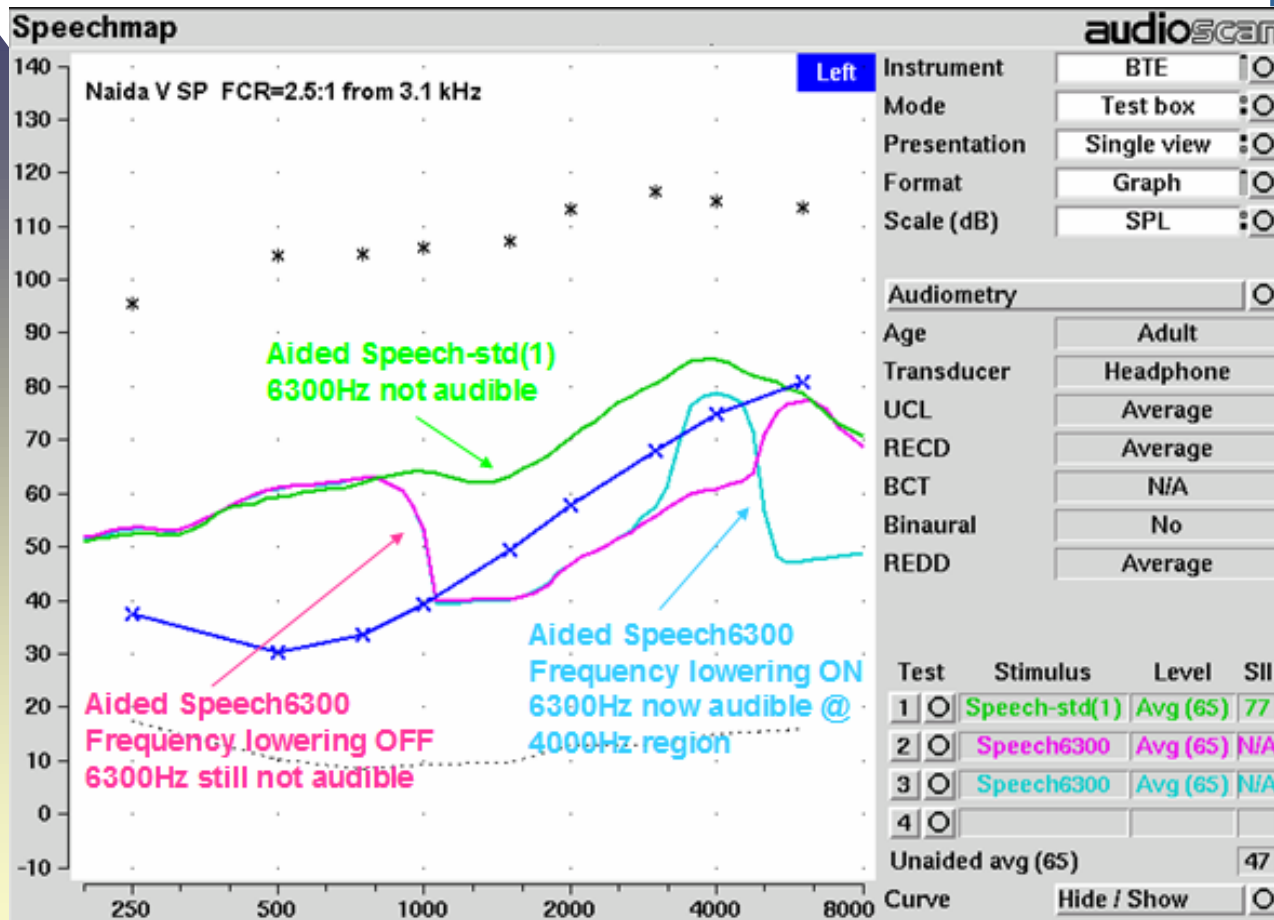
Software Release V3.4

- Main New Features
 - ◆ Frequency Lowering Verification

Frequency Lowering Input Stimuli



Frequency Lowering Test Result Example

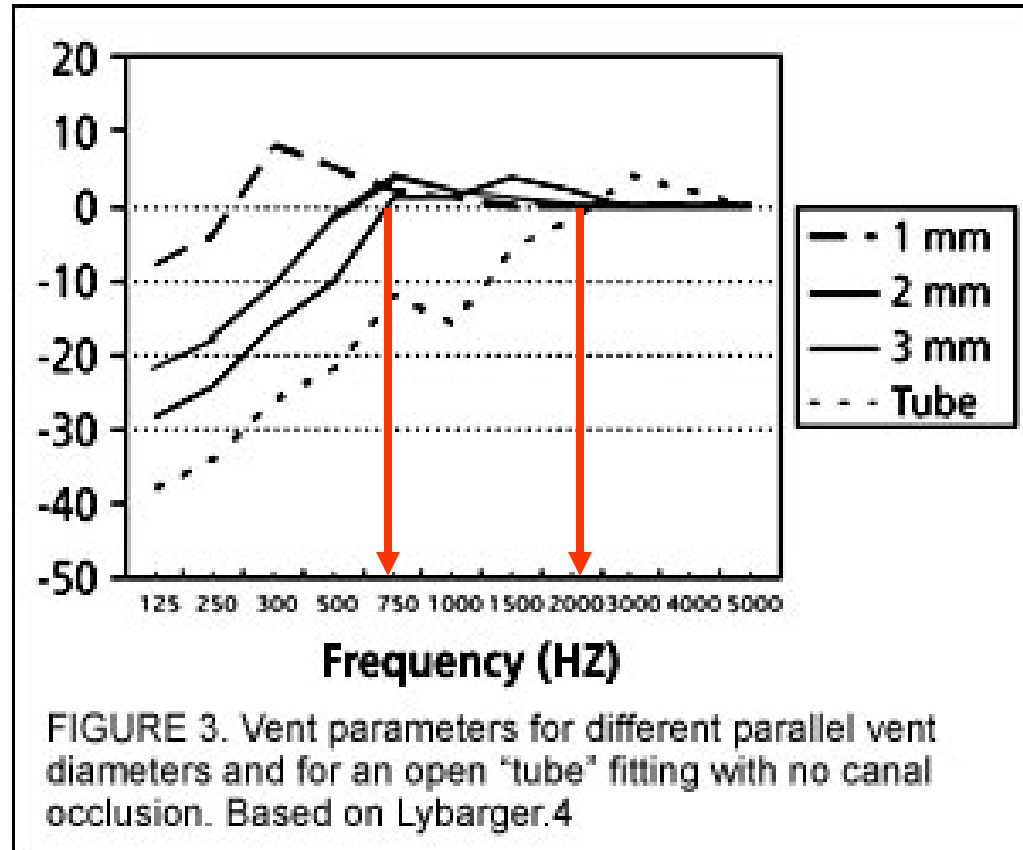


Speech Mapping of Open-Fit (Thin-Tube) Technology



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Minimal Occlusion



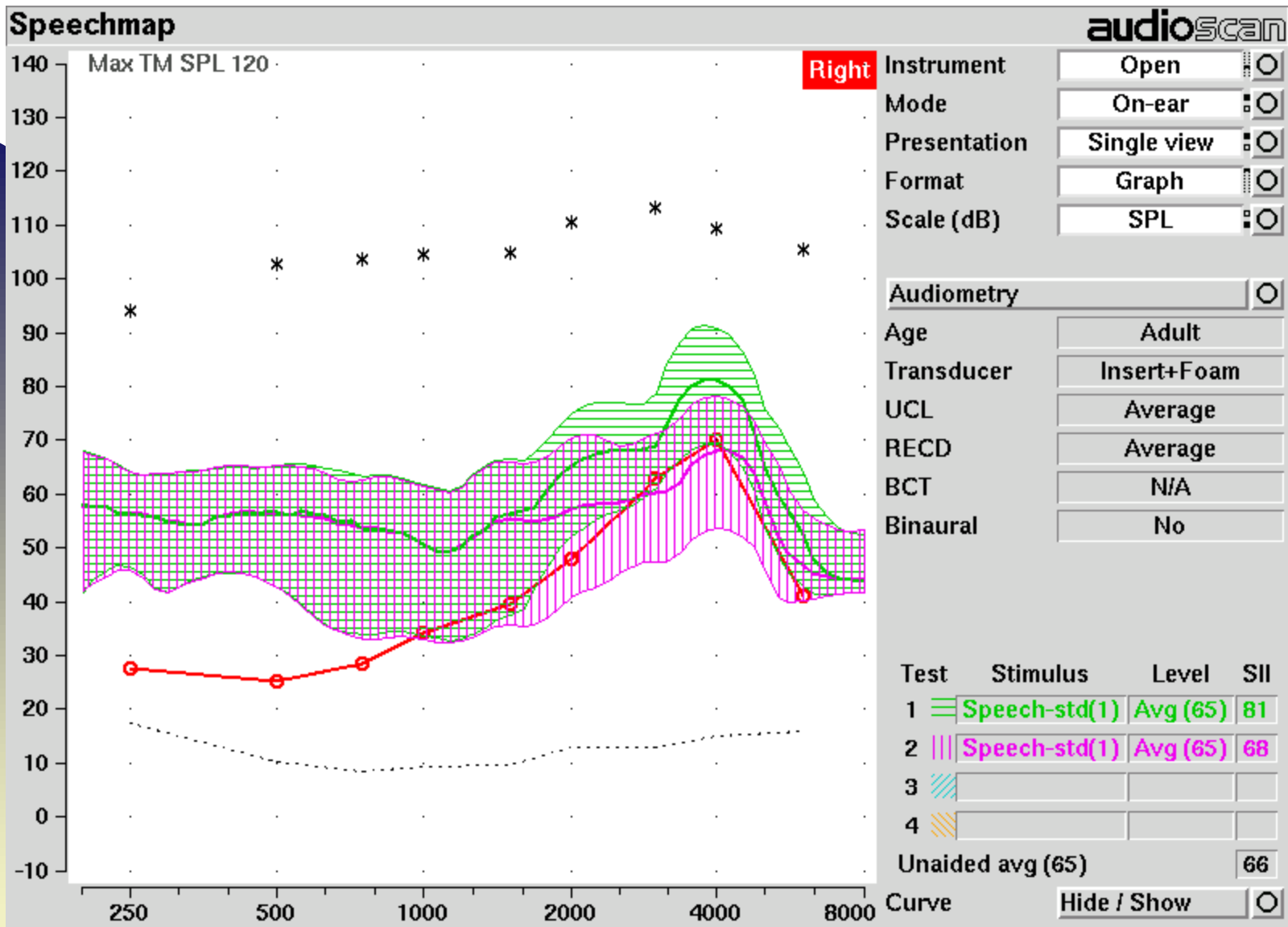


FIGURE 5: The pink shaded area is the eardrum SPL “speech banana” for 65dB speech input measured at the probe tip with the open-fit hearing aid turned OFF. The green shaded area is the eardrum SPL “speech banana” with the same hearing aid turned ON. The difference between the two indicates where amplification has reached the eardrum.

Verifying Digital Performance

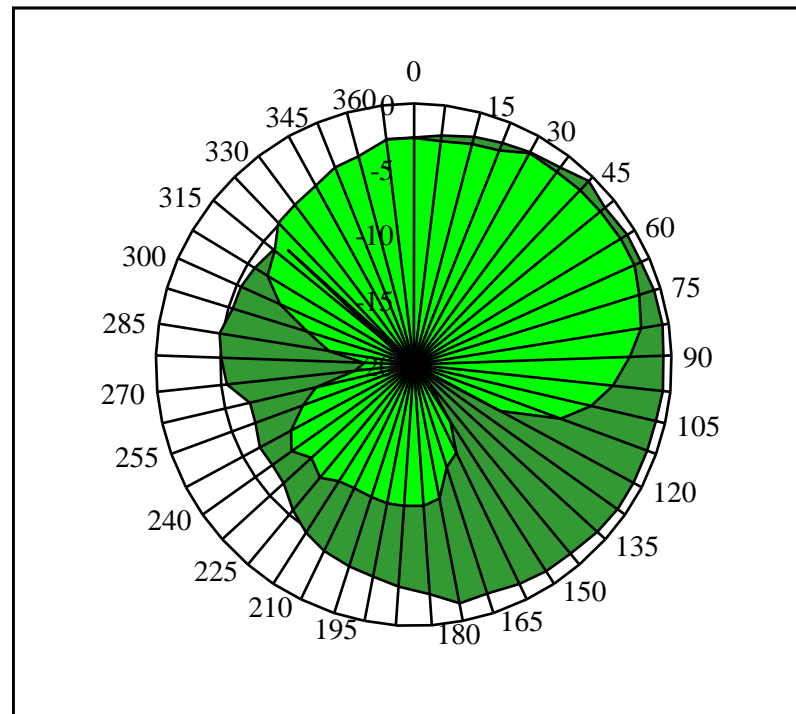
2) Verifying Directionality Function



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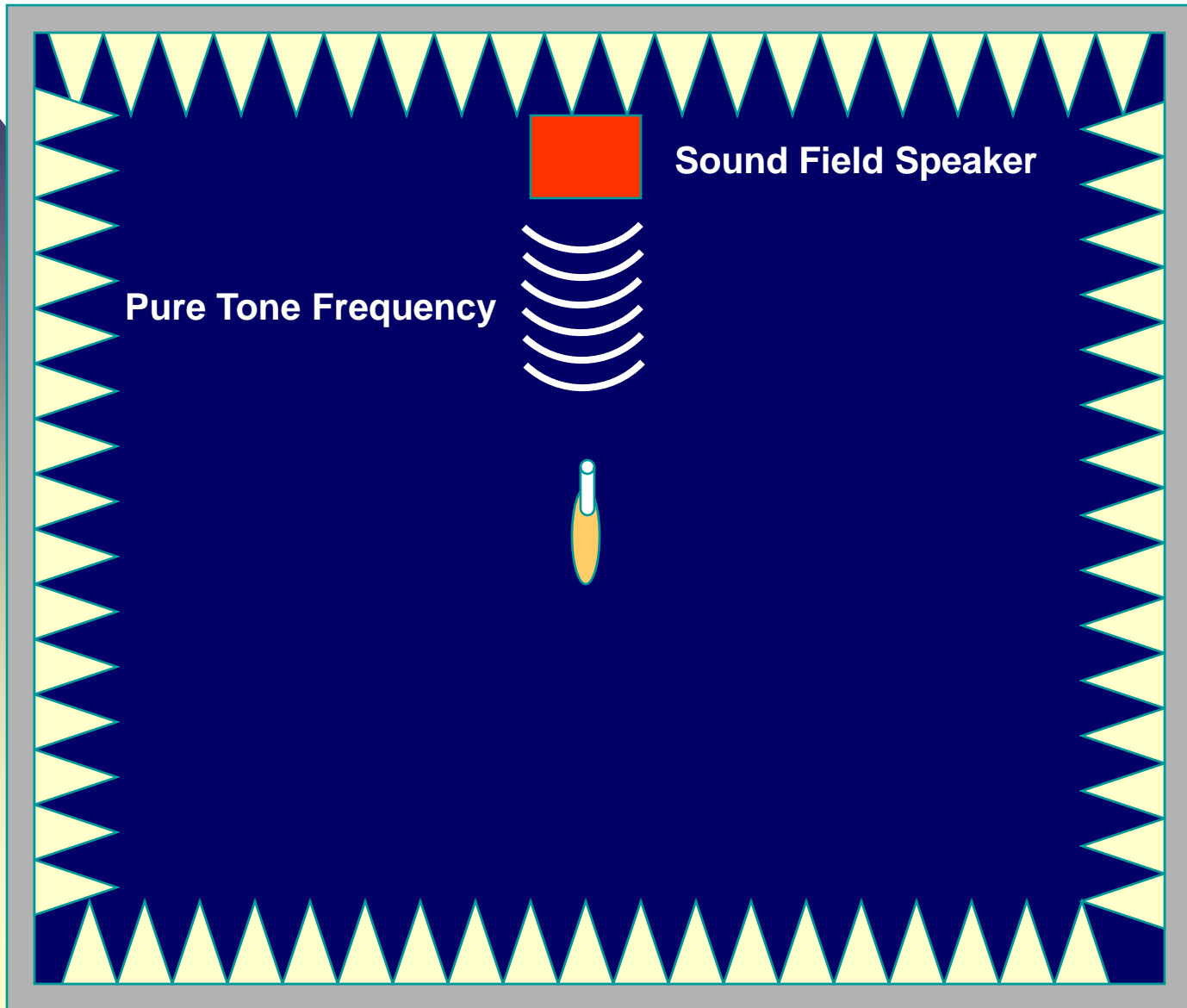
Laboratory Specification of Directionality

Polar Plots



2) Directional Verification

Conventional Directional Microphone Test (Polar Plot Measurement)



Anechoic Chamber

Issues Associated with Conventional Polar Plot Testing

- Polar plots are obtained in the presence of a single pure tone frequency
- Polar plots do not measure in the presence of multiple input sources
- Polar plots can not be obtained in the presence of non-linear (compression) amplification

A New Way of Measuring Directional Microphone Performance



Obtaining a Directional
Microphone Frequency Response
in the Presence of Multiple Input
Source Locations



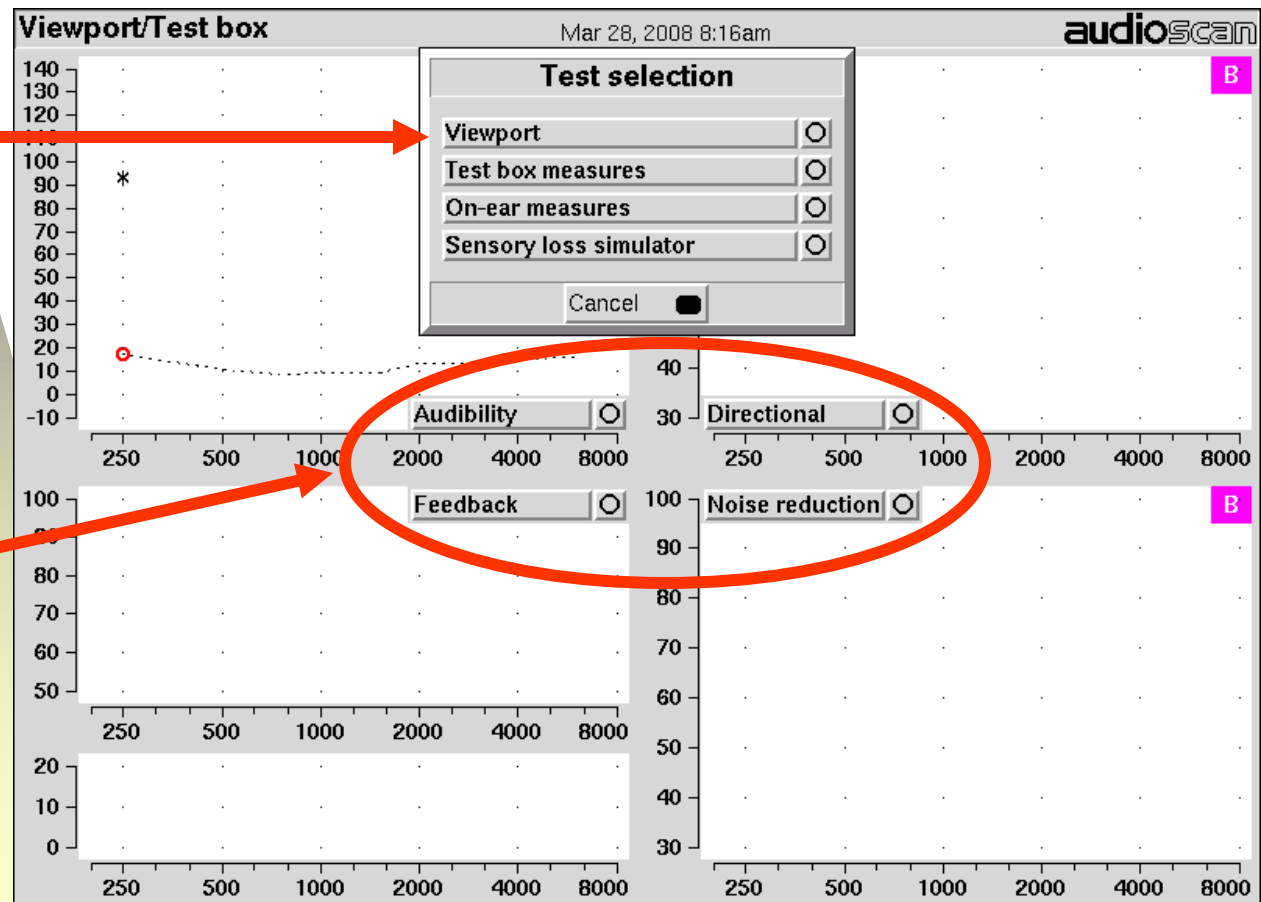
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Viewport: Digital Functions Summary/ Test Protocol Screen

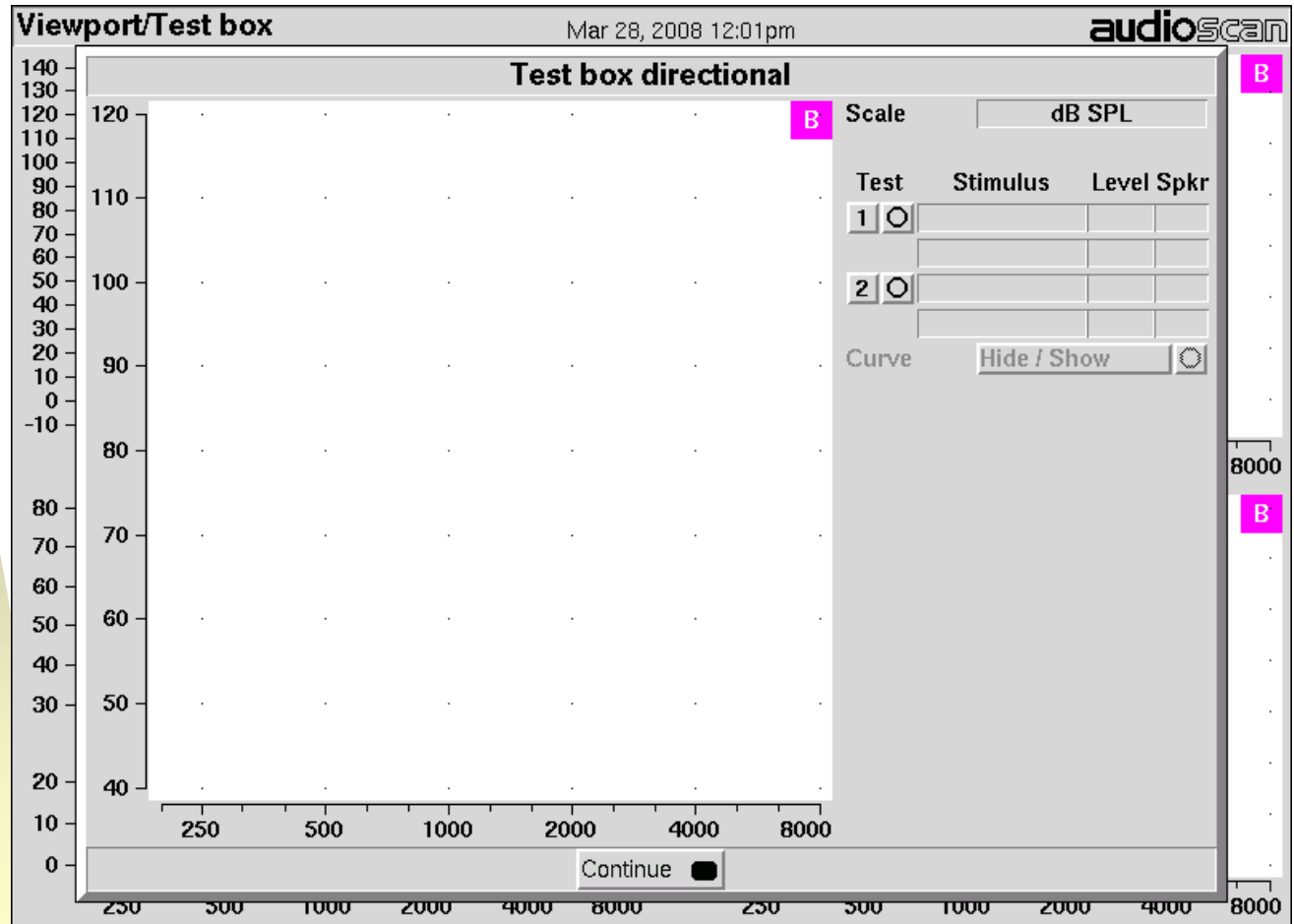
Contains both
“Test Box” and
“On Ear” Options

4 quadrants – one
for each of the 4
digital functions
tests

Pre-set (but
adjustable)
protocols

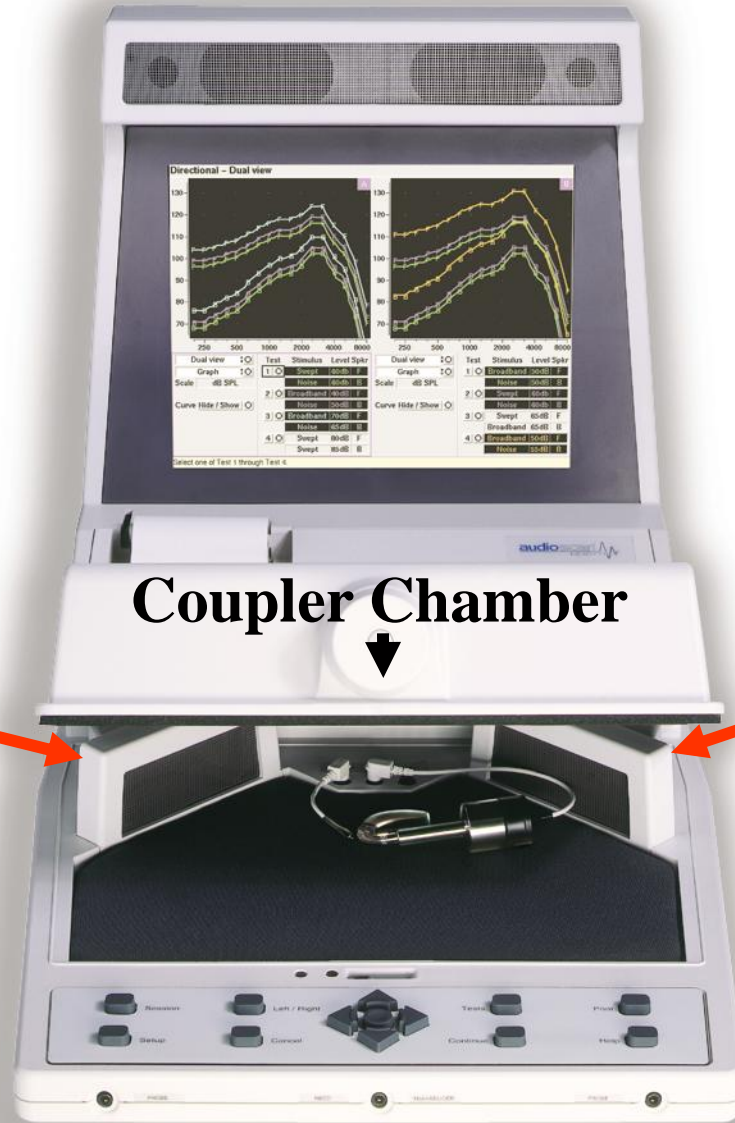


Viewport Directional Test Quadrant - Open



Select Test 1 or Test 2.

Verifit Testing System Hardware

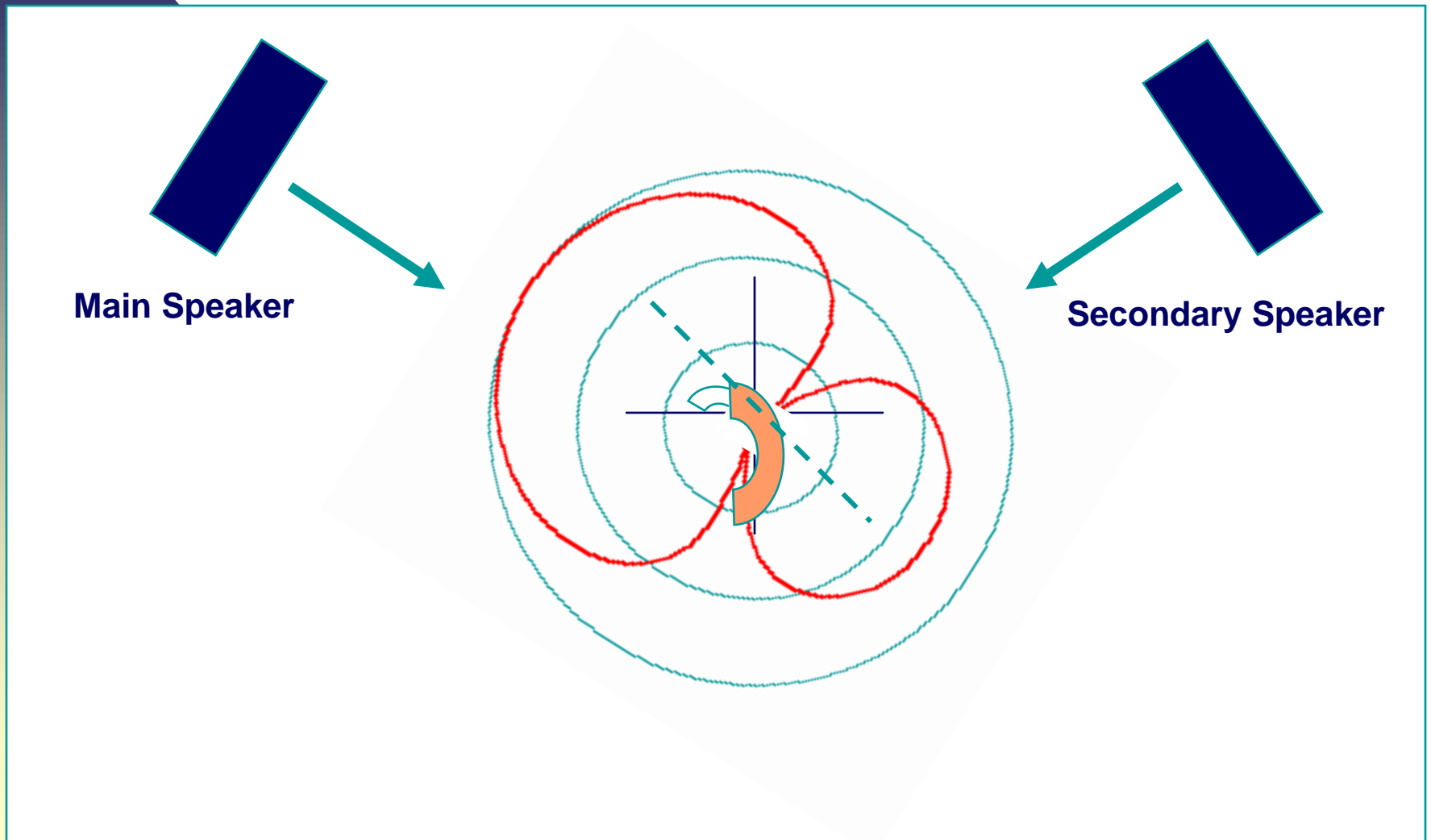


Main Signal Source



Coupler Chamber

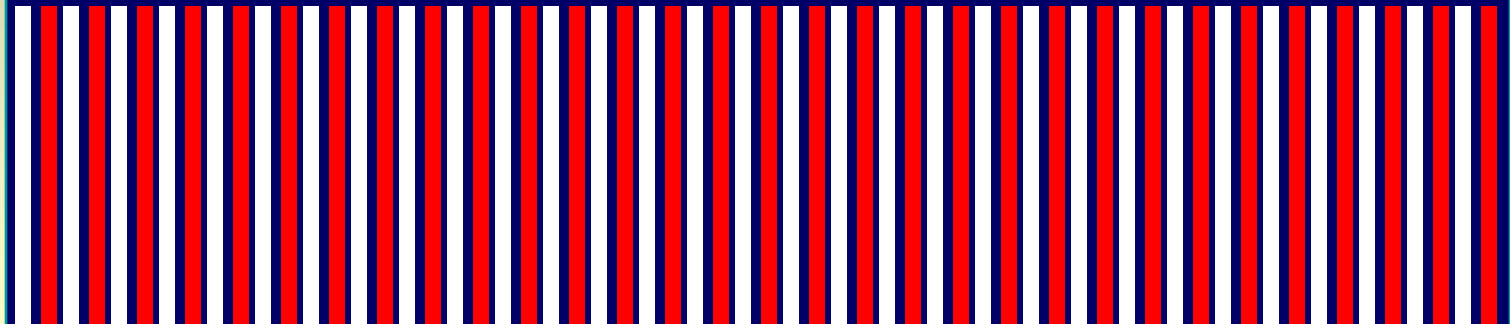
Secondary Signal Source

Recommended Hearing Aid Positioning In Test Box



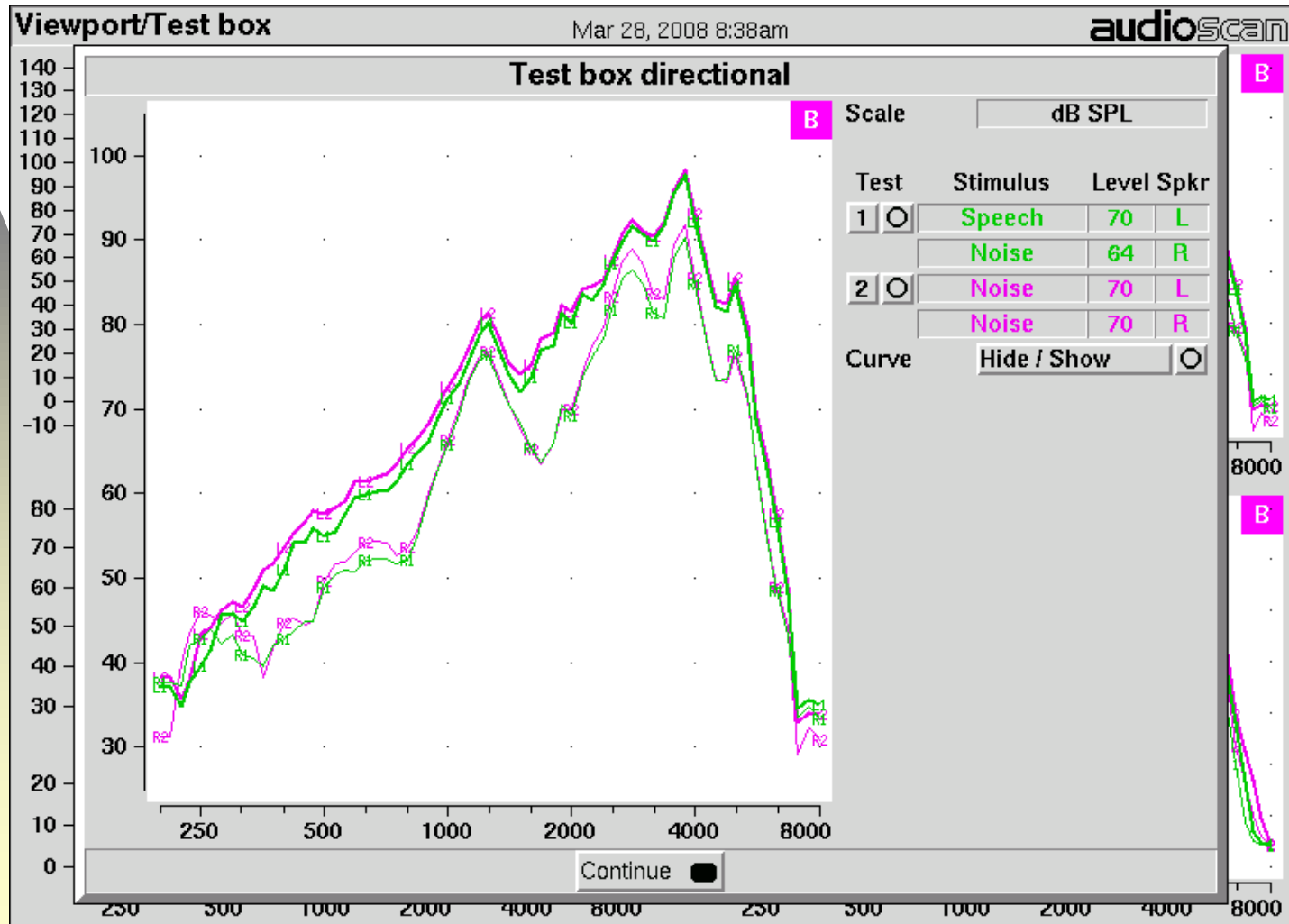
Directional Frequency Response Input Stimulus

-  = Main input signal (512 pure tones 7.8Hz apart)
-  = Secondary input signal (512 pure tones 7.8 Hz apart)



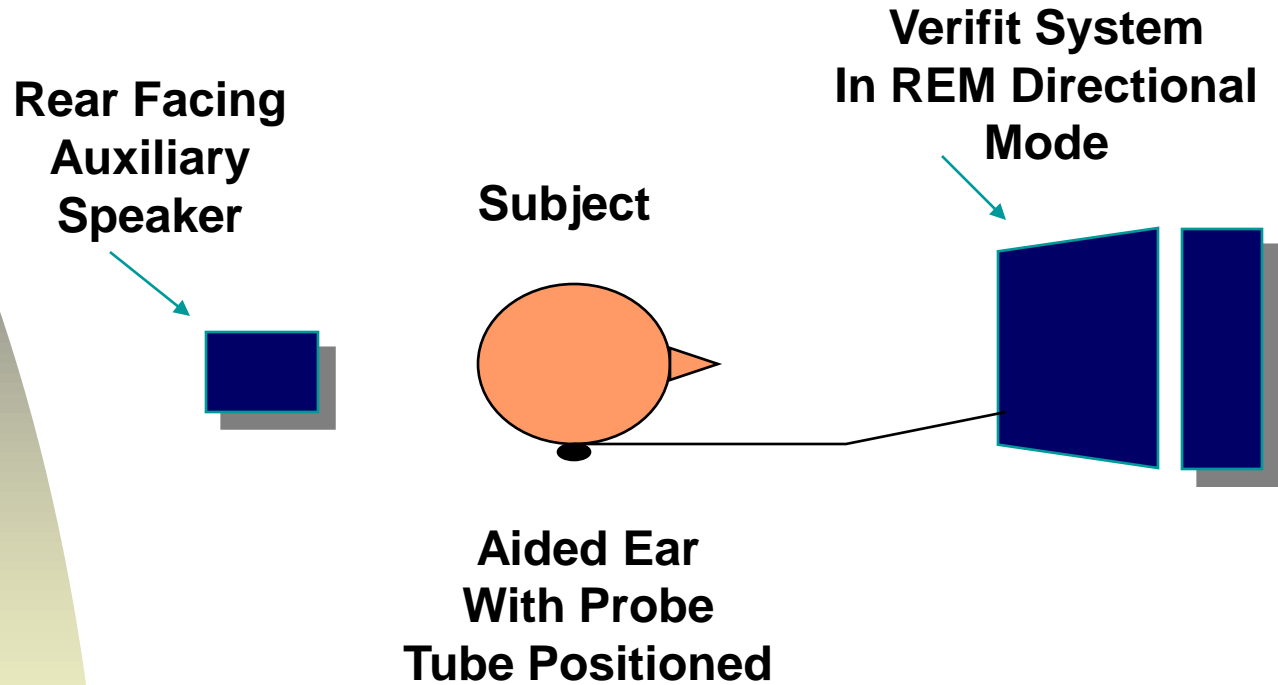
Frequency (KHz) 

Viewport Directional Test Box Result



Select Test 1 or Test 2.

Directionality Test (REM)



2) Directional Verification

Open-Fit and Directional Mics

- Run “Directional” test in the box
- Compare directional frequency response separation in the aided frequency response region
- Curve separation in the aided region implies directional advantage available
 - ◆ Compare lower curve to “unaided” banana “noise-floor”

Verifying Digital Performance

3) Verifying Noise Reduction Function

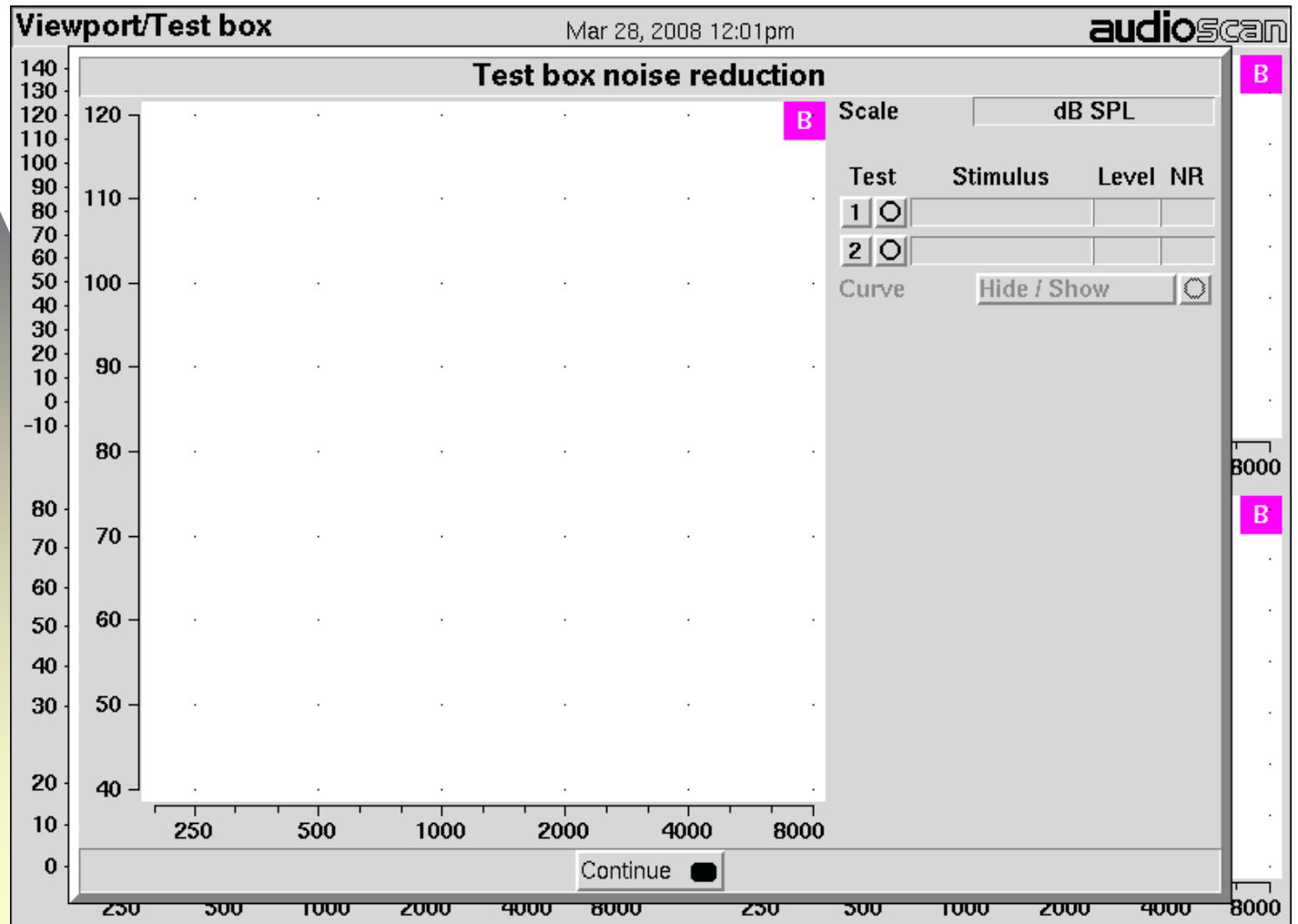


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Digital Noise Reduction Properties

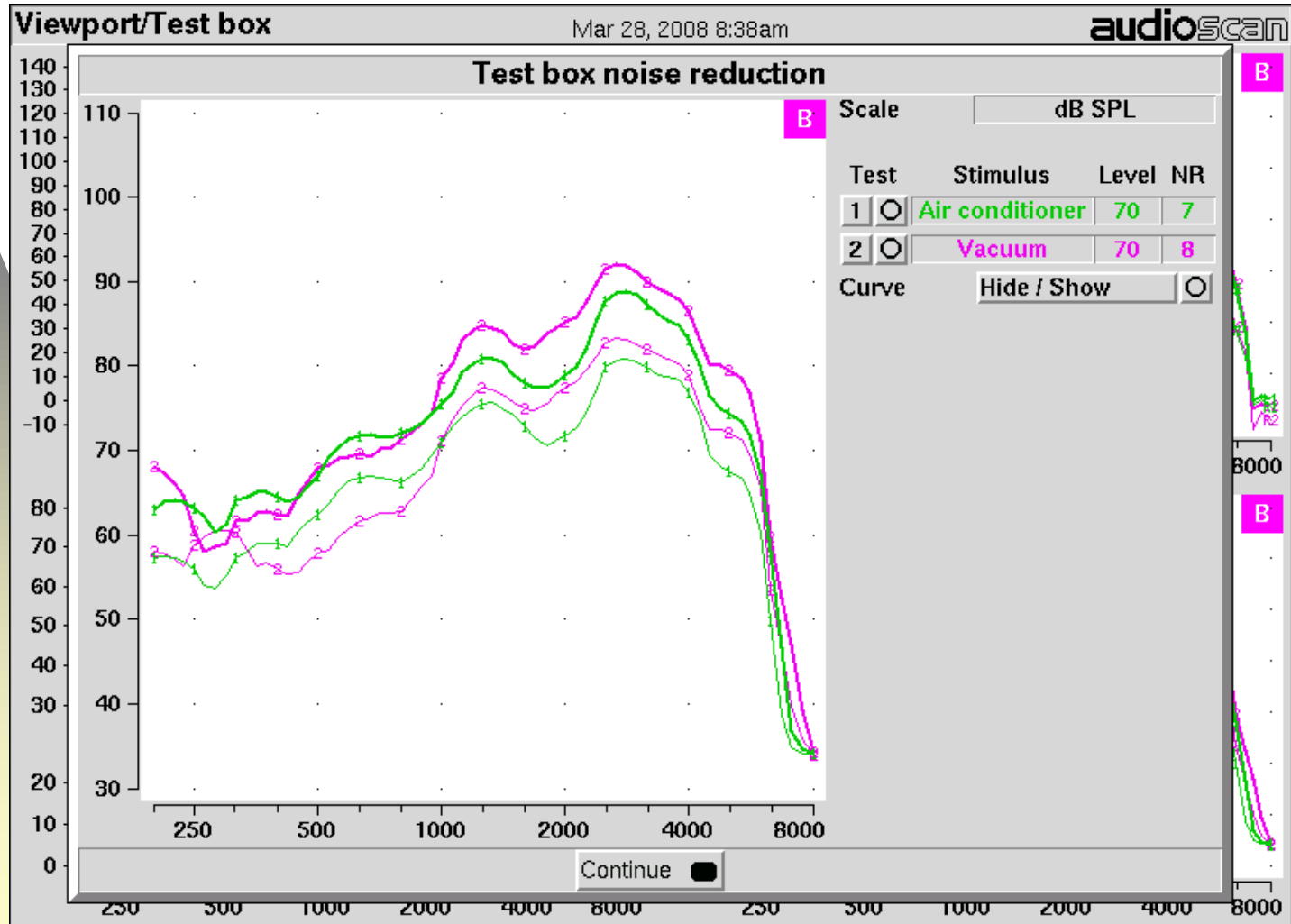
- Digital algorithm programmed to recognize “non-speech” elements of incoming stimulus
 - ☞ Operates independently in bands
 - ☞ Analyzes incoming signal modulation
- Can vary in terms of time constants
 - ☞ Typically, slow attack, fast release

Viewport Noise Reduction Test Box Quadrant - Open



Select Test 1 or Test 2.

Viewport Noise Reduction Test Result



Select Test 1 or Test 2.

Verifying Digital Performance

4) Verifying Feedback Reduction Function



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Digital Feedback Reduction Properties

Active

Passive

**Phase
Canceller**

**Notch
Filter**

Best Overall Application	
	Poorest Overall Application

Key Factor of Concern

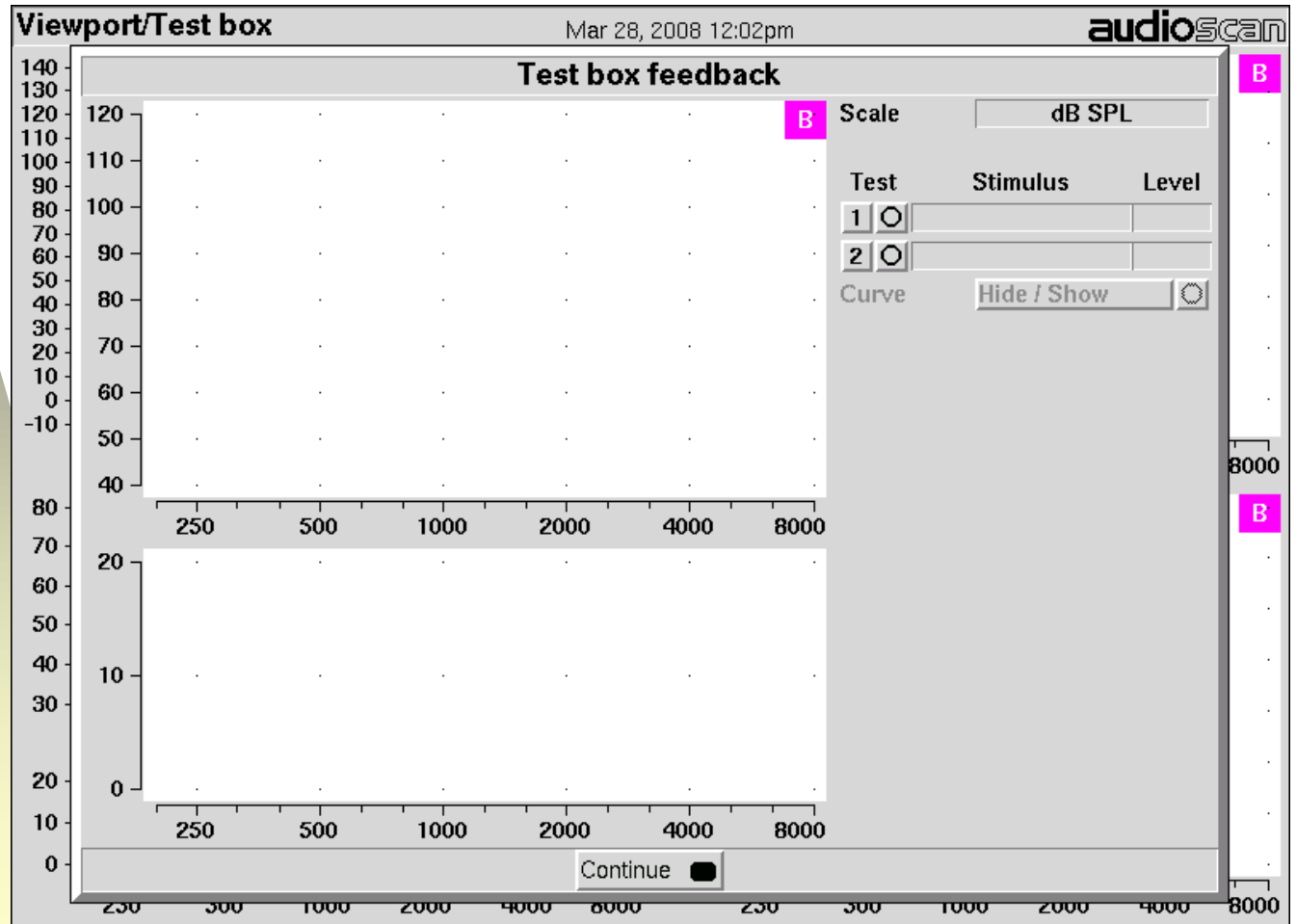
- Does the feedback suppression function compromise hearing instrument performance when processing other stimuli?

**4) Feedback
Reduction
Verification**

Interactive Feedback Reduction Measurement

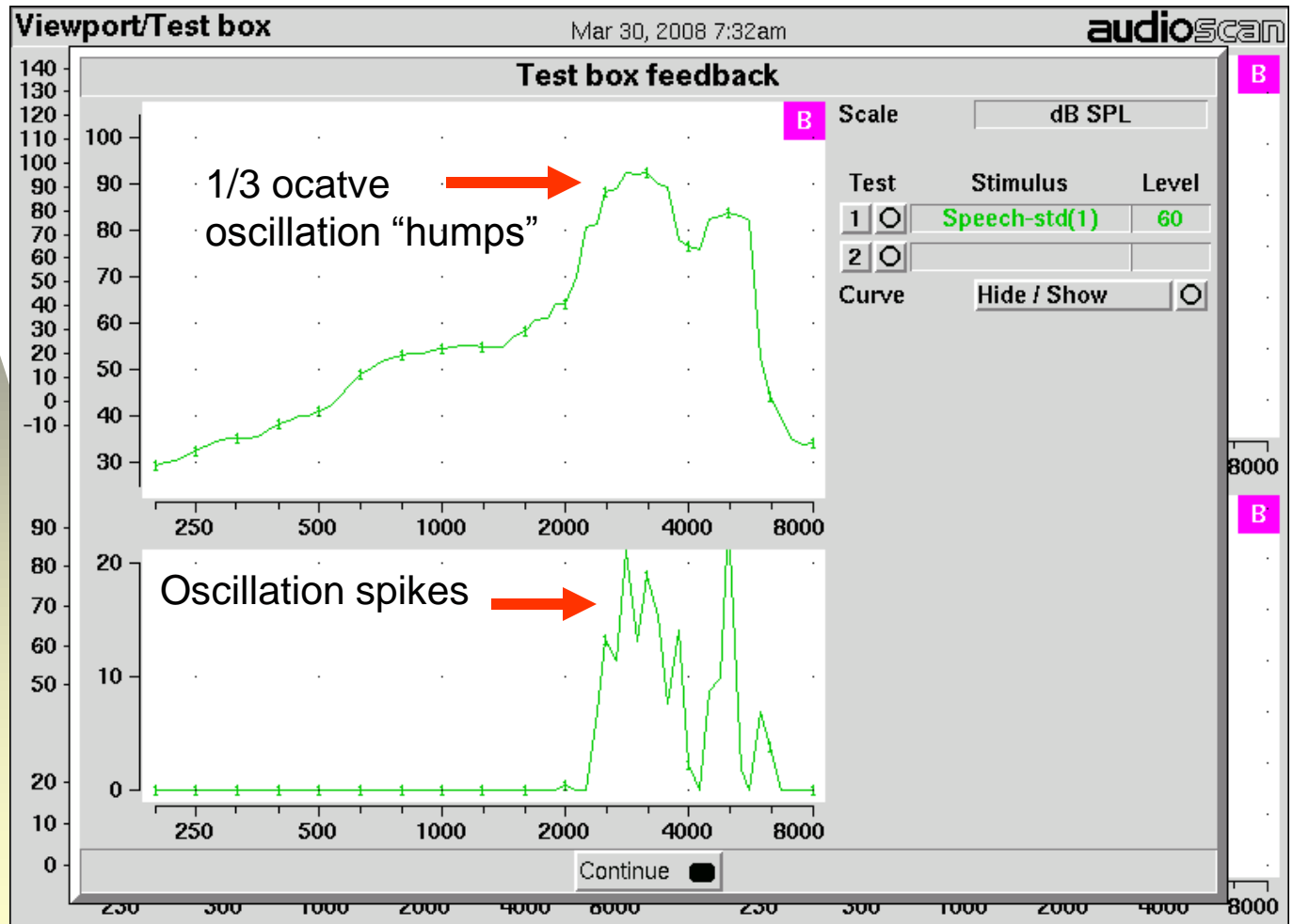


Viewport Feedback Test Box Quadrant - Open



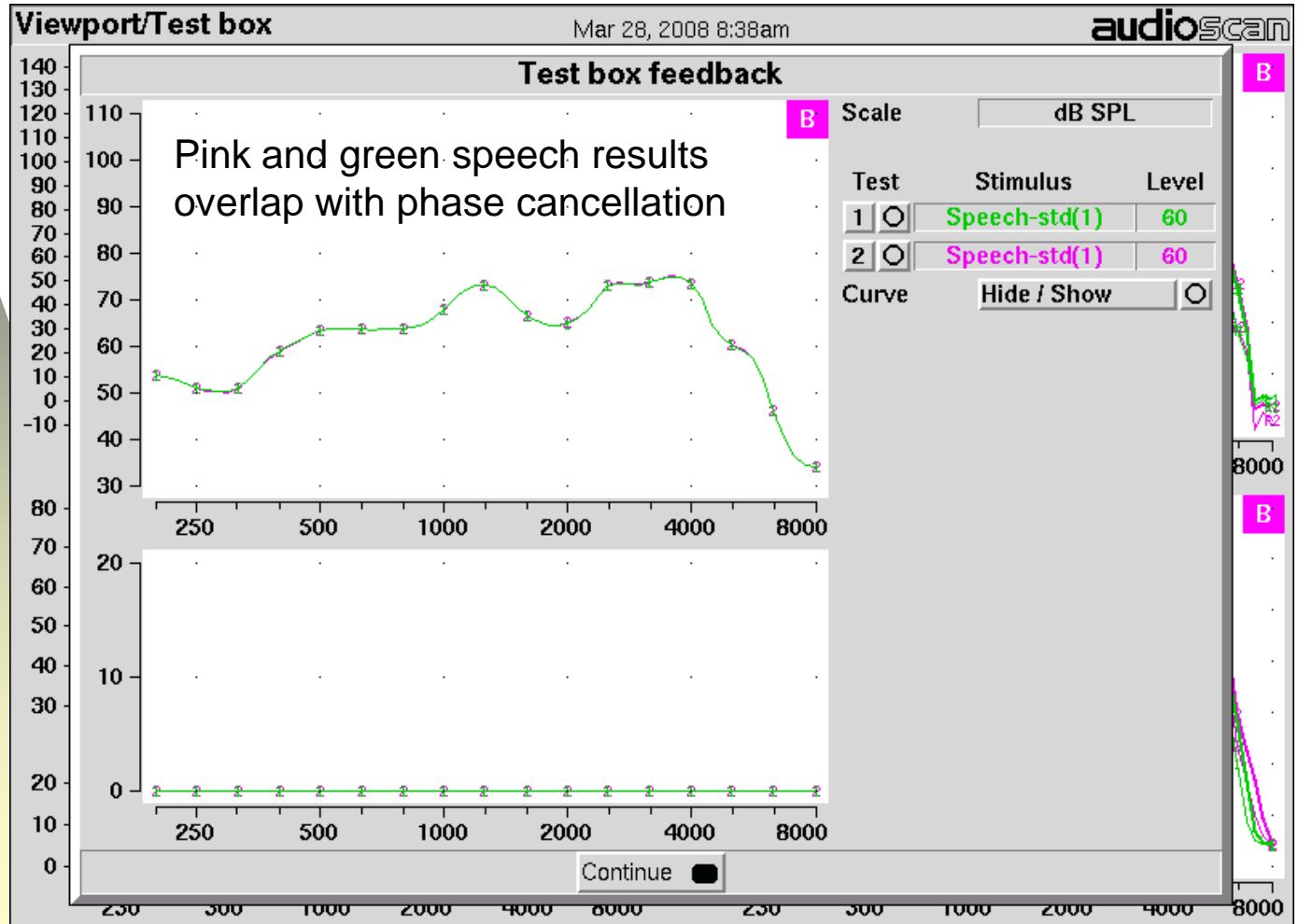
Select Test 1 or Test 2.

Expected Display When Feedback is Induced By Monitoring Headset



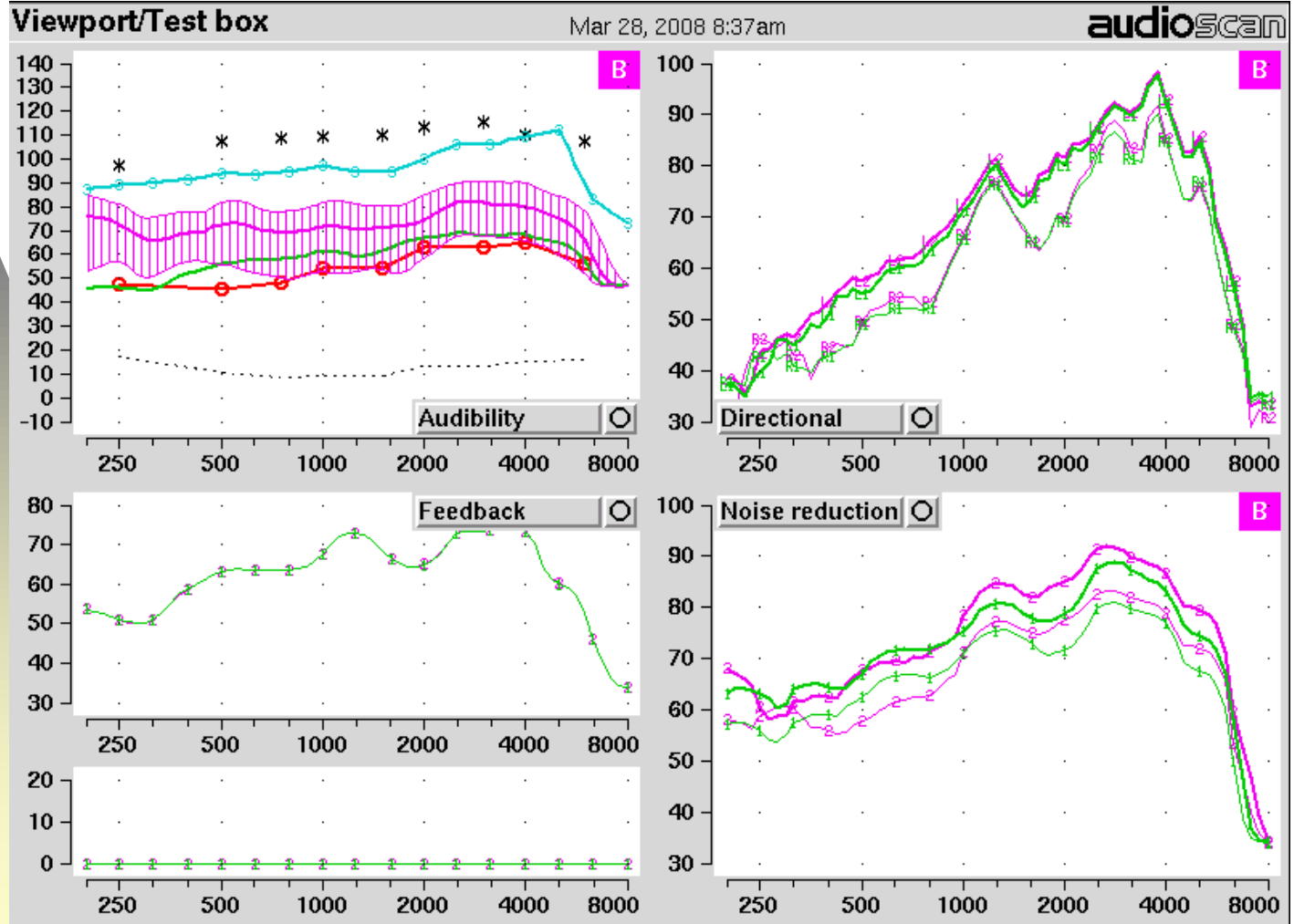
Select Test 1 or Test 2.

Viewport Feedback Box Test Result



Select Test 1 or Test 2.

Viewport Final Results Screen



Select a test.

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